PRELIMINARY HYDROGEOLOGICAL ASSESSMENT
RICARDO RANCH AREA STRUCTURE PLAN
RICARDO RANCH, IN SOUTHEAST CALGARY, ALBERTA

Submitted To:

Brookfield Residential Inc.
Genesis Land Development Corp.
Mr. Sandy Soutzo

Submitted By:

Waterline Resources Inc.
Calgary, AB
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Waterline

EXECUTIVE SUMMARY

Waterline Resources Inc. was retained by Brookfield Residential Inc., Genesis Land Development Corp. and Mr. Sandy Soutzo to update the existing hydrogeological conceptual model in support of the Ricardo Ranch Area Structure Plan (ASP) in Southeast Calgary, Alberta. The Ricardo Ranch ASP is part of a greater ASP Development, which comprises approximately 1,346 hectares of land in the southeast quadrant of Calgary, south of the Seton Urban District. Ricardo Ranch is located within Sections 9, 10 and 11, and parts of Sections 3 and 4, of Township 22, Range 29, West of the Fourth Meridian. Its boundaries are marked by Highway 2 (Deerfoot Trail) and the Bow River.

The bulk of the previous work completed at Ricardo Ranch was focused within the plateau area, a terrain setting present throughout the majority of the proposed development. Based on Waterline's review there appeared to be three groundwater flow systems present: a series of shallow, localized, small-scale perched groundwater systems present on the plateau; a deeper, intermediate-scale groundwater system present within the Crossfield Drift; and, a regional-scale groundwater system present in the bedrock aquifers.

The refined preliminary conceptual model of groundwater flow along the escarpment demonstrated that a local to intermediate flow system controls the discharge of groundwater from inter-till aquifers which occur as springs and seeps along the escarpment, and a regional flow system controls the discharge of groundwater from the bedrock at the base of the escarpment. Based on the conceptual model, it was determined that potential exists for the project to reduce infiltration along the plateau which may reduce vertical flow through the till, horizontal flow within the inter-till aquifers, and discharge from the associated springs and seeps, but is unlikely to impact flow to the underlying bedrock and associated bedrock springs.

Based on the conclusions of the report, Waterline provided several recommendations which included identifying and evaluating all the seeps along the escarpment and preparing a long-term water management plan. Recommendations for management of the springs and seeps along the escarpment included groundwater monitoring and dewatering systems, depending on whether maintaining flow to the springs is required by AEP or the city. It was also noted that the current landowner has installed infrastructure to utilize, direct and manage a spring sustained from the bedrock aquifer and that a specific water management plan may be required with input from AEP and/or the city to determine an acceptable plan for the spring and its associated infrastructure. Further, if a complete hydrogeological assessment is deemed to be required per the LID Module 1 MDP, Waterline recommended developing a work plan to identify the gaps in the hydrogeological assessment, including soil infiltration rates and seasonal variability of the water table and springs, throughout the Ricardo Ranch ASP.

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1.0 INTRODUCTION

Waterline Resources Inc. (Waterline) was retained by Brookfield Residential Inc., (Brookfield) Genesis Land Development Corp. (Genesis) and Mr. Sandy Soutzo to update the existing hydrogeological conceptual model in support of the Ricardo Ranch Area Structure Plan (ASP) in Southeast Calgary, Alberta. Assessment of the ASP is required by the City of Calgary (the city) in compliance with the Low-Impact Development (LID) Module 1 Master Drainage Plan (MDP). MDPs are used to support ASPs in addressing the potential for impacts on groundwater caused by a development and storm water management systems.

The Ricardo Ranch ASP is part of a greater ASP Development, which comprises approximately 1,346 hectares of land in the southeast quadrant of Calgary, south of the Seton Urban District. Ricardo Ranch (the study area) is located within Sections 9, 10 and 11, and parts of Sections 3 and 4, of Township 22, Range 29, West of the Fourth Meridian. Its boundaries are marked by Highway 2 (Deerfoot Trail) and the Bow River, as shown on Figure 1.

1.1 Background and Previous Studies

The Ricardo Ranch ASP includes stormwater drainage works that will follow a LID approach. A LID is a development (residential or commercial) that minimizes the impact of stormwater on watersheds by integration of measures to detain, retain and treat stormwater using soil infiltration and percolation to redirect a portion of the stormwater back into the hydrologic cycle (EBA, 2014). LID projects for the city should comply with guidelines presented in the document *Low Impact Development Project. Module 1 – Geotechnical and Hydrogeological Considerations* (EBA, 2014) and referred to as LID Module 1 in this report.

The LID Module 1 defines several planning levels following a staged approach, each being more refined than the previous one:

- Watershed Plans (WP) or Water Management Plans (WMP);
- Master Drainage Plans (MDP);
- Staged Master Drainage Plans (SMDP);
- Pond Reports; and
- Stormwater Management Reports (SWMR) both for subdivision plans and private Development Site Servicing Plans (DSSP).

The project is currently at the MDP stage, for which preliminary geotechnical and hydrogeological assessments are required. To date, several of these assessments and investigations have been completed as part of the ASP, including:

- A sanitary tunnel feasibility geotechnical investigation along 210 Avenue SE (Thurber Engineering Ltd. [Thurber], 2007);

- A geotechnical investigation of SW-15-22-29 W4M (Jacques Witford AXYS Ltd. [JWA], 2007);
- A geotechnical evaluation of Danube Farms (M·L, 2012);
- A desktop hydrogeological assessment of the Rangeview ASP (Golder Associates [Golder], 2014);
- A geotechnical investigation of the South Seton Subdivision (Stantec Consulting Ltd. [Stantec], 2014);
- A desktop geotechnical investigation of the Bow River Escarpment (McIntosh Lalali Engineering Ltd. [M·L], 2014),
- A geotechnical evaluation of Rangeview Cell C (M·L, 2015);
- Preliminary soil and groundwater investigation along the Rangeview Sanitary Trunk (AECOM Canada Ltd. [AECOM], 2017); and
- A preliminary slope stability analysis of Rangeview Cell E ASP (M·L, 2017).

1.2 Objective

The bulk of the previous work completed at Ricardo Ranch was focused within the plateau area, a terrain setting present throughout the majority of the proposed development. Waterline was retained to complete a site reconnaissance and desktop assessment of the hydrogeology along the escarpment located in the study area and prepare a preliminary conceptual hydrogeological model in support of the Ricardo Ranch ASP.

The site visit and in-field data collection discussed in this document (e.g. spring water sampling) were limited to the Genesis property only. However, the desk-based data compilation included here includes the Genesis property and the surrounding areas, including the entire Plan area. In addition to the assessments listed in Section 1.1, Waterline reviewed publicly available data from multiple regional scale studies and data sources.

Waterline understands that the groundwater flow systems present at Ricardo Ranch extend well beyond the Genesis property boundary. For that reason, Waterline included results from local assessments and larger-scale publicly available information sources into this document.

1.3 Scope of Work

Waterline proposed to complete a preliminary hydrogeological assessment based on the previously completed assessments and investigations, augmented by information available for domestic and agricultural use water wells located within Ricardo Ranch, and other publicly available data sources. Although this information will not completely satisfy the technical requirements of the MDP LID Module 1 hydrogeological investigation, it does provide the level of detail required to develop a comprehensive conceptual hydrogeological model for the proposed development area and assess data gaps. The associated scope of work included:

- Completion of a field reconnaissance that focused on the escarpment, an area of steep slopes grading to the Bow River valley;
- Conceptualization of the interaction between groundwater and surface water along watercourses and in the vicinity of wetlands and marshes to aid in protecting habitats from loss of groundwater discharge/recharge or receipt of poor quality surface drainage;
- Completion of a desktop review of surficial geology and soils, topography, hydrology, and hydrogeology, including an assessment of regional and local aquifers, and develop a conceptual hydrogeological model to support the MDP; and
- Providing recommendations with respect to further studies and monitoring that may be required to meet the conditions of the LID Module 1 MDP.

1.4 LID Module 1 Concordance Table

A table containing the technical requirements of the LID Module 1 are included in Table 1 (below). Previous technical investigations have addressed most of the requirements. Some of the requirements (i.e., groundwater flow rate) cannot be provided without additional monitoring and assessments.

Table 1: Current Status of MDP Technical Requirements from LID Module

Technical Requirement of LID Module 1	Comment
Characterize the interaction between groundwater and surface water along watercourses and in the vicinity of wetlands and marshes to assess slope stability and aid in protecting habitats from loss of groundwater discharge/recharge or receipt of poor-quality surface drainage.	Groundwater and surface water interactions have been identified at Ricardo Ranch along the escarpment and Bow River terrace, through a combination of desktop review of available information and field observations. The Soutzo Spring was included in the fieldwork because it is the most prominent groundwater discharge present in the Ricardo Ranch area.
Assessing slope stability issues and the potential impact of declining water levels on aquatic habitats.	Slope stability issues are addressed by M·L under a separate cover. The potential impact of declining water levels on aquatic habitats at the base of the escarpment have been identified as a potential concern at the Soutzo Spring. However, the Soutzo Spring appears to be sustained by groundwater sourced from the shallow bedrock and is unlikely to be impacted by the development. Waterline recommends preparation of a water management plan for the Soutzo Spring to minimize the potential impact on the adjacent aquatic habitat. The potential impact of declining water levels on aquatic habitats along the escarpment may be a potential concern. However, groundwater discharging along the escarpment is likely sourced from the Crossfield Formation till, and the catchment area of these groundwater discharge features likely extends to areas that have already been developed upgradient of the escarpment. The cumulative effects of the existing developments in the catchment area on the volume of groundwater discharging from the Crossfield Formation till was not determined prior to building the existing developments.
Determine the direction and rate of groundwater flow.	The direction of groundwater flow in the Crossfield Formation till and the Scollard Formation Bedrock has been assessed and described as generally southward, with groundwater discharging along the escarpment. The rate of groundwater flow through the Crossfield Formation till or the Scollard Formation Bedrock is presently unknown. Additional groundwater investigations would be required to quantify the groundwater flow rates.

Evaluate the potential hydraulic conductivity of the soil above the water table (infiltration rates and percolation rates, i.e., the vertical hydraulic conductivity).	Qualitative assessment of groundwater infiltration rates on the plateau were completed by Golder (2014). Vertical hydraulic conductivity of the fluvial sediments in the Bow River valley is unknown. As described above, additional groundwater investigations are necessary to quantify the groundwater flow rates.
Assessing the baseline ground water chemical quality.	Baseline groundwater chemical quality of the Crossfield Formation till was completed by AECOM (2017). Baseline water chemistry of springs sourced from the Scollard Formation at the base of escarpment has been completed and reported by Waterline (2018). Baseline water chemistry of groundwater discharges sourced from the Crossfield Formation till is unknown at present and require additional sampling and lab analyses.

2.0 PHYSICAL FRAMEWORK

2.1 Study Area

There are three primary terrain settings identified by Golder (2014) at Ricardo Ranch:

- Plateau: undulating agricultural land, with seasonal wetlands in the north of the development area;
- Escarpment: steep, sparely vegetated slopes susceptible to land wasting; and
- Terraces and Valley: sands and gravels adjacent to the Bow River.

A figure from Golder (2014) illustrating the location of the terrain settings at Ricardo Ranch is available in Appendix A. All three terrain settlings are present within the study area.

2.2 Topography and Drainage

Topography at the study area is dominated by the escarpment, which runs west to east across the entire study area. Ground elevations on the plateau above the escarpment range from approximately 1,025 to 1,040 metres above sea level (masl). There is a narrow bench, referred to as the mid-slope bench, present within the escarpment on the west side of the study area at a ground elevation of approximately 1,010 masl. Below the escarpment, sands and gravels are observed at surface with a ground elevation ranging from approximately 985 to 990 masl. The topography of the study area is shown on Figure 2.

Drainage at the study area is directed downslope, south, towards the Bow River. Erosional drainage features and slumping are common along the escarpment in the study area.

2.3 Surface Water Features

The Bow River is a regional-scale surface water feature that forms the southern boundary of the study area. A small surface water feature containing open water was observed at the base of the escarpment, which appears to be sustained by a nearby flowing spring (Soutzo Spring; Figure 2) draining east toward a channel of the Bow River. Numerous springs and seepages are present along the escarpment.

2.4 Geology

The surficial geology of the plateau and escarpment in the study area have been mapped as the glacially deposited Crossfield Drift by Moran (2008; Figure 3). The Crossfield Drift is described as consisting of clay-dominated (Unit A) and sand and silt-dominated (Unit B) till sediments. Below the escarpment, Moran (2008) identifies Empress Formation sediments as well as fluvial-channel sediments, originating from the Bow River, consisting of sands and gravels. The regional geology is shown on the regional cross-sections A and B, developed by Moran (2008) that occur proximal to the study area (Figure 5).

Based on boreholes described in the geotechnical programs summarized in Section 1.1, the till sediments at Ricardo Ranch are described as clay-dominated sediments with interbedded coarse-grained fluvial materials, consistent with the descriptions provided by Moran (2008). Using these geotechnical boreholes, three local cross-sections were developed across the study area (Figure 4) and are provided as cross-section C-C' (Figure 6), D-D' (Figure 7) and E-E' (Figure 8). Raw data points and fence diagrams of the data used to prepare Figures 6 to 8 are shown for reference on Figure B-1 in Appendix B. As shown, the primary sediments underlying the study area are fine-grained till deposits with interbedded thin sand and gravel units that do not appear to be laterally extensive across Ricardo Ranch. None of the wells shown in the cross-sections intersected the underlying bedrock. The only well reported to intersect bedrock in the study area is BH4 completed by M·L (2017; Figure 2). BH4 is located on the eastern edge of the escarpment within the study area and intersected bedrock at a depth of 40 metres below ground level (mbgl).

Based on mapping presented by the Alberta Geological Survey (AGS), the uppermost bedrock formation at Ricardo Ranch is identified as the Paskapoo Formation, a Paleocene aged combination of alluvial sandstones, siltstones and mudstones (Prior et al., 2014). The Paskapoo Formation is underlain by the Scollard Formation, an upper Cretacous to lower Paleocene aged unit also consisting of alluvial sandstones, siltstones and mudstones. An outcrop of the Scollard Formation is present at the base of the escarpment on the eastern side of the study area. The outcrop is described as containing light brown, fractured, siltstones and fine-grained sandstones. An unconsolidated sand and gravel unit was observed immediately above the unconformity that represents the top of the bedrock.

2.5 Hydrogeology and Groundwater Resources

As a whole, groundwater resources at Ricardo Ranch appear to be under-drained by the presence of the escarpment. Groundwater is observed discharging along the escarpment in the form of springs and seeps, as demonstrated by field observations and the declining groundwater level reported in the boreholes shown in the local cross-sections. Waterline field staff did not observe evidence of water in the form of surface water or groundwater-related seeps or springs within the erosional drainage features present along the escarpment. Potential groundwater resources at Ricardo Ranch were identified by Golder (2014) as:

- shallow groundwater present in the Crossfield Drift;
- inter-till glacio-fluvial sand and gravel deposits; and
- bedrock aquifer.

Shallow groundwater present within the Crossfield Drift has been identified during previous borehole drilling programs completed at Ricardo Ranch. Golder (2014) characterized the shallow groundwater as belonging to a perched groundwater system, present on the plateau.

Deeper boreholes and groundwater monitoring wells completed at Ricardo Ranch have identified the presence of a till aquifer on the plateau, in the glacially deposited sediments at depths greater than 6 metres below ground level (mbgl). AECOM (2017) completed monitoring wells within the study area in these deeper till sediments with hydraulic conductivities ranging from 10^{-7} to 10^{-5} m/s. Golder (2014) noted that while post-glacial sand and gravel deposits are found in the Buried Calgary Valley (Mayboom, 1961), these deposits are expected to be scarce at Ricardo Ranch. Based on field collected observations, glacio-fluvial sand and gravel deposits within the till unit have been identified in the vicinity of the escarpment within the study area in borehole logs and outcrops, and form discontinuous, local scale inter-till glacio-fluvial aquifers. A series of seeps and springs along the western portion of the escarpment in the mid-slope bench study area appear to be sustained by groundwater sourced from the inter-till glacio-fluvial aquifers.

Based on a review of water well drilling reports from the Alberta Environment and Parks Groundwater Information Centre (GIC) Water Well Database (AEP, 2018), fractured Paskapoo and Scollard formations form a bedrock aquifer present at Ricardo Ranch. There are eleven GIC database records located within Ricardo Ranch, six of the eleven database records plot within the study area (Table 2).

Table 2: GIC Water Well Database Records within Ricardo Ranch

Well ID	Study Area	Location	Depth (mbgl)	Date	Owner	Use	Type
131732	Yes	07-10-022-29-W4M	12.2	Jan 1, 1940	Soutzo, C.G	Domestic	Chemistry
286254	Yes	07-10-022-29-W4M	39.6	May 28, 1997	A.G. Scout 20	Domestic	New Well
131733	Yes	SW-11-022-29-W4M	61.0	Unknown	Alsip, R.H.	Domestic	Chemistry
131734	Yes	NW-11-022-29-W4M	91.4	Unknown	Shepherd Landfill	Domestic	Chemistry
131748	No	SE-22-022-29 W4M	54.0	Dec 14, 1977	Wenngatz Construction	Domestic and Stock	New Well
131749	No	SE-22-022-29 W4M	0	Unknown	Jensen, Carol	Domestic	Chemistry
131750	No	01-22-022-29 W4M	10.7	April 1, 1955	Texaco Exploration Company	Industrial	Flowing Shot Hole
131753	No	22-022-29 W4M	0	Unknown	Tammaro, Carl	Domestic	Chemistry
292945	Yes	04-10-022-19 W4M	22.86	Sep 10, 1999	Ham, Wayne	Domestic	New Well
297347	Yes	SE-09-022-29 W4M	0	Jul 12, 2001	EBA Engineering Consulting Ltd	Industrial	Old Well - Abandoned

Notes: “mbgl’ means metres below ground level.

The bedrock aquifer has been the primary source of domestic water use at Ricardo Ranch, with records dating back to the 1940’s. Water wells 286254 and 292945 are completed in bedrock sediments and located at the base of the escarpment in the study area. Waterline field staff observed groundwater discharging from the bedrock aquifer at the bedrock outcrop along the eastern base of the escarpment, and a nearby designed spring (Soutzo Spring) in the study area.

3.0 GROUNDWATER ï STUDY AREA

3.1 Groundwater Flow Patterns

A contour map of the groundwater level in the till aquifer was generated using the available groundwater level data and is provided as Figure 9. The groundwater elevation surface was derived from boreholes that were completed 6 metres or more below ground level. It should be noted that the groundwater level surface presented in Figure 9 represents the top of the water table in the inter-till glacio-fluvial aquifers and excludes groundwater levels measured in the shallow perched groundwater system present on the plateau. Groundwater levels in the glacio-fluvial inter-till aquifers appears to decrease from north to south across the plateau, from approximately 1,040 masl to less than 1,014 masl, after which the groundwater level begins to decline rapidly along the escarpment. This indicates that groundwater is flowing in the till aquifer from north to south with a gradient of approximately 1% on the plateau. When compared with ground elevation (Figure 2), it appears that the water table remains at least 10 meters lower than the ground surface on the plateau but is at or near to ground surface along the escarpment. This is supported by the evidence of springs identified along the escarpment, which manifest as areas of increased vegetation and the presence of recently formed cemented gravels.

Water well records indicate non-pumping groundwater levels measured in bedrock wells within and around Ricardo Ranch occur from 1,020 to 980 masl along the plateau and flows south toward the Bow River (Figure 10). The groundwater elevation of the bedrock is lower than the overlying water table and drift sediments, and therefore, groundwater appears to have a slight downward vertical component near the site from the drift deposits, recharging the bedrock aquifers.

Groundwater flow in the study area is interpreted to be topography driven, with the plateau region being defined as recharge area, and the escarpment and regional lowlands being defined as discharge areas. The Bow River valley is considered the main regional discharge area towards which regional bedrock flow is expected to converge. The occurrence of low permeability till deposits of the Crossfield Formation till restricts local-scale flow beneath the plateau and vertical infiltration. The cutbank of the escarpment exposes the underlying glacial deposits, and the Paskapoo/Scollard formation bedrock in some sections, which are part of an intermediate to regional flow system. The exposure of coarse-grained glacial (fluvial) sediments and bedrock along the escarpment provides a discharge location for groundwater flow along the overburden-bedrock interface resulting in under-draining of the overlying sediments, which is discussed further in Section 4.0.

3.2 Baseline Groundwater Chemistries

Two springs were sampled by Waterline during the field reconnaissance program at locations shown on Figure B-2 in Appendix B. The field parameters and geochemical results of the spring samples were used to evaluate the relative age of the groundwater in order to identify its potential source as derived from overburden or bedrock. The first spring was sampled along the eastern embankment of the study area from which water was observed to be flowing from bedrock outcrop and along the bedrock-overburden interface, occurring adjacent to the Bow River. The second spring (Soutzo Spring) sampled was a developed source used by the current landowner for stock watering, the discharge of which flows along the ground surface to the east, paralleling the escarpment to the north and Bow River to the east (Figure 2). A copy of the analytical certificates and laboratory results are provided in Appendix C.

The rationale for choosing to collect groundwater samples for laboratory analysis from these sites is as follows:

- The Soutzo Spring was known to exist and the water quality at the spring was an identified data gap in the CSM;
- The unnamed spring site was identified during the site visit. Upon identification of the Spring, Waterline staff in the field collect a groundwater sample from the spring to determine if the origin of the spring was the same as the nearby Soutzo Spring.

The spring-water samples collected by Waterline indicated that the groundwater discharging at the two locations sampled along the escarpment was a bicarbonate to sulphate-type water with no dominant cation, with a TDS concentration ranging from 800 to 820 mg/L. The geochemical signature suggests that the groundwater has chemically evolved from its source as precipitation, indicating that the water has undergone interaction with sediments over time. The water chemistry results collected from the two bedrock springs are similar to the GIC database water chemistry record (Well ID 131732) associated with a shallow bedrock well located at the base of the escarpment within the study area.

The geochemistry of the bedrock sourced spring water samples is different from the reported geochemistry of the groundwater sampled from monitoring wells within the study area installed as test holes along the sanitary trunk by AECOM (2017). The AECOM monitoring wells, completed across the water table at depths ranging from 11 to 24 mbgl along the plateau, were characterized as calcium bicarbonate-type water with a TDS concentration ranging from 370 to 520 mg/L.

When comparing the shallow groundwater and spring chemistry to bedrock groundwater chemistry data extracted from the GIC Water Well Database (AEP, 2018), the data indicate that the underlying Scollard Formation hosts bicarbonate-type water in the shallow system (12 mbgl; GIC Well ID 131732) and sodium sulphate-type groundwater in the deep bedrock (91 mbgl; GIC Well ID 131734).

The water quality results from the escarpment springs, the AECOM monitoring wells within the study area, and the GIC bedrock wells, are plotted on a Piper diagram presented as Figure 11. As shown on the figure, the geochemistry plots into three distinct groups:

- Sodium sulphate-type groundwater from a deep bedrock aquifer;
- Calcium sulphate-bicarbonate-type water from the well and springs completed in the shallow bedrock aquifer; and
- Calcium bicarbonate-type water from the till aquifer.

3.3 Surface Water and Groundwater Interactions

Golder (2014) interpreted the water table on the plateau to have generally little to no interaction with the ground surface due to the low permeability of the underlying Crossfield Formation till. It was noted however that slope failures had occurred along the escarpment which culminated in mounds of colluvium accumulated at the base of the slopes with increased vegetation occurring along the seepage face. This interpretation was supported by the field program conducted by Waterline in June 2018 where the surface gravels were found to be naturally cemented, forming conglomeratic boulders extending across the western slopes of the escarpment. Waterline also identified springs along the escarpment extending through the eastern section of the study area where Scollard Formation bedrock outcrop, resulting in seepage from fractured bedrock and along the bedrock-overburden interface.

4.0 DISCUSSION

4.1 Conceptual Hydrogeological Model

Based on a review of previous investigations and studies, publicly available information and field-based observations collected at the study area, there appears to be three groundwater flow systems present:

- A series of shallow, localized, small-scale perched groundwater systems present on the plateau, which may be infiltrating groundwater vertically, deeper into the Crossfield Drift;
  - Groundwater in this system is sourced entirely from snow melt and precipitation;
- A deeper, intermediate-scale groundwater system present within the Crossfield Drift where glacio-fluvial sediments with relatively higher hydraulic conductivities are present;
  - Groundwater in this system is presumably sourced from a combination of existing groundwater present upgradient in the Crossfield Drift and snow melt/precipitation infiltrating from low lying surface depressions such as ponds and ephemeral wetlands present on the plateau;
- A regional-scale groundwater system present in the bedrock aquifers;
  - Groundwater in this system is sourced from recharge occurring over a large region north of the study area.

The groundwater flow systems described above are consistent with groundwater flow systems of Alberta originally described by Toth (1963). Local flow systems are controlled by local topography. Regional flow systems originate from the highest hill (recharge areas), discharging into the deepest valley. Intermediate flow systems are developed between these two extreme cases. By applying this model to the project area, the bedrock flow system is classified as an intermediate to regional system, whereas groundwater flow in the drift deposits is characterized as an intermediate to local flow system.

An illustrative interpretation of the conceptual hydrogeological model is presented for the western portion of the study area as Figure 12 and the eastern portion of the study area as Figure 13.

This updated conceptual site model provides the current level of understanding of the groundwater flow systems at the study area, focused within the Ricardo Ranch development. The model may be used to support future hydrogeological investigations to be completed at and around the Ricardo Ranch development during more detailed land use planning stages. Such investigations may include the design, completion and operation of the monitoring system(s).

4.2 Impact of the Project

If the conceptual hydrogeological model presented in Section 4.1 correctly identifies infiltrating precipitation on the plateau as a significant source of recharge to the inter-till glacio-fluvial aquifers, although these aquifers are considered discontinuous and local in extent, the potential exists for changes in the quantity and/or quality of groundwater discharging from the inter-till aquifers in the form of springs and seeps along the escarpment. It should be noted that significant land use changes, in the form of recently built developments, have already occurred upgradient of the seeps which are likely to have an impact on the quantity and quality of groundwater in the inter-till glacio-fluvial aquifers that sustain the seeps, regardless of the proposed Ricardo Ranch development. It is unknown what impact the existing development will have on the seeps,

Existing and proposed developments on the plateau will likely decrease the volume of infiltration into the inter-till aquifers which will result in a corresponding decrease in the volume of water discharging along the escarpment, particularly along the mid-slope bench.

It should be noted that if land use changes cause an increase in the volume of water infiltrating into the inter-till aquifers, such as focused infiltration into a small area, the potential exists for a corresponding, potentially localized, increase in the volume of water discharging along the escarpment. Similarly, a change in the quality of the water infiltrating into the inter-till aquifers on the plateau will likely result in a similar change in the quality of the water discharging along the escarpment.

Based on the conceptual hydrogeological model, groundwater present in the bedrock aquifer is likely sourced from recharge that occurs on a regional scale. Therefore, it is unlikely that precipitation infiltrating from the plateau at Ricardo Ranch contributes significantly to the volume of water present in the bedrock aquifer. Project-related land use changes on the plateau are unlikely to significantly alter the volume of water discharging from the bedrock aquifer at existing springs, including the Soutzo Spring. However, land use changes along the escarpment have the potential to alter the location of springs and volume of water discharging from springs at the base of the escarpment.

5.0 CONCLUSIONS AND RECOMMENDATIONS

A preliminary conceptual model of groundwater flow along the escarpment contained within the Ricardo Ranch ASP was completed through a desk-based compilation and a field-based assessment of the escarpment. The conceptual model demonstrates that a local to intermediate flow system controls the discharge of groundwater from inter-till aquifers which occur as springs and seeps along the escarpment, and a regional flow system controls the discharge of groundwater from the bedrock at the base of the escarpment. Based on the conceptual model, there is potential that the existing and proposed developments on the plateau may reduce vertical flow through the till, horizontal flow within the inter-till aquifers, and discharge from the associated inter-till aquifer sourced springs and seeps but is unlikely to impact flow to the underlying bedrock and associated bedrock springs.

The connection between surface water present on the plateau and the water-table present within the Crossfield Formation till is likely limited due to the presence of low conductivity silts and clays within the Crossfield Formation till. Some infiltration of surface water from the plateau does occur, however, due to the presence of the low conductivity materials, the infiltration rates are likely very low, and a large infiltration area is required to sustain water levels in the Crossfield Formation till.

Water samples collected in 2018 appear to indicate that the groundwater discharging from the shallow bedrock is a mixed source of younger water from the Crossfield Formation till and older, more evolved groundwater sourced from the deep bedrock aquifers.

Based on the conclusions of this report, Waterline provides the following recommendations:

- Collect water samples from select seeps along the escarpment to compare the water chemistry to the groundwater samples collected from monitoring wells installed in the inter-till glacio-fluvial aquifers.
- Prepare a plan to maintain and manage the Soutzo Spring, including steps to protect the spring during construction and a long-term plan for the spring and its associated infrastructure. The City of Calgary recommends that the Parks Business Unit be consulted during the development of a long-term plan for the spring.
- If a complete hydrogeological assessment is required per the LID Module 1 MDP, develop a work plan to identify the above indicated gaps in the hydrogeological assessment, including soil infiltration rates and seasonal variability of the water table and springs, throughout the Ricardo Ranch ASP.

6.0 CERTIFICATION

This document was prepared under the direction of a professional geologist, geoscientist or engineer registered in the Province of Alberta.

Waterline Resources Inc. trusts that the information provided in this document is sufficient for your requirements. Should you have any questions or concerns, please do not hesitate to contact the undersigned.

Respectfully submitted,

Waterline Resources Inc.
APEGA Permit to Practice No. P07329

Aug 8, 2019

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8.0 LIMITATIONS AND USE

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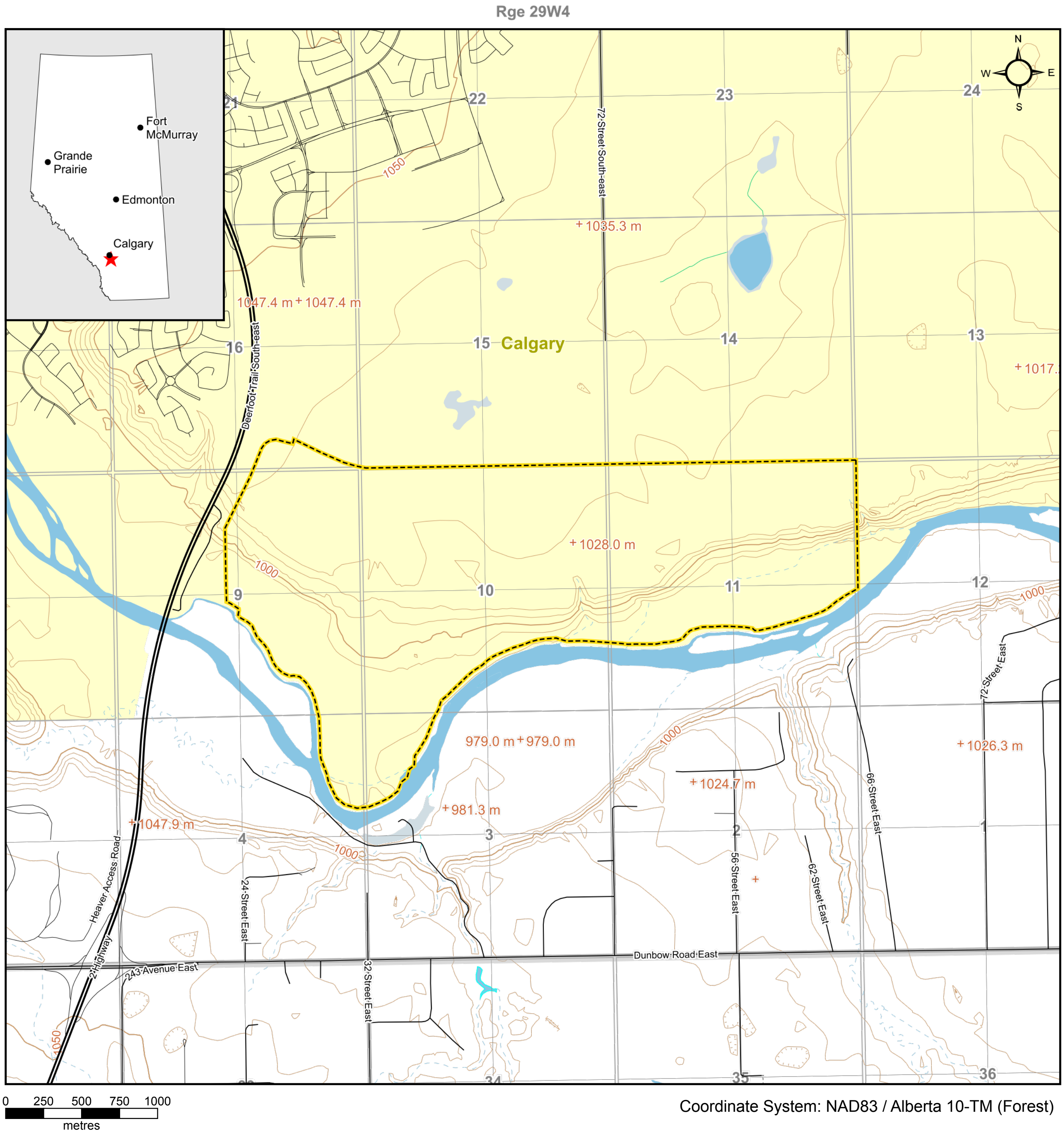
FIGURES



Coordinate System: NAD83 / Alberta 10-TM (Forest)

Site Boundary

Permanent Lake, River

Ephemeral Lake

Reservoir, End-pit Lake

Ephemeral Stream

Ephemeral Drainage Pathway

Man-made Canal/Ditch/Spillway

Contour

Depression Contour

Index Contour

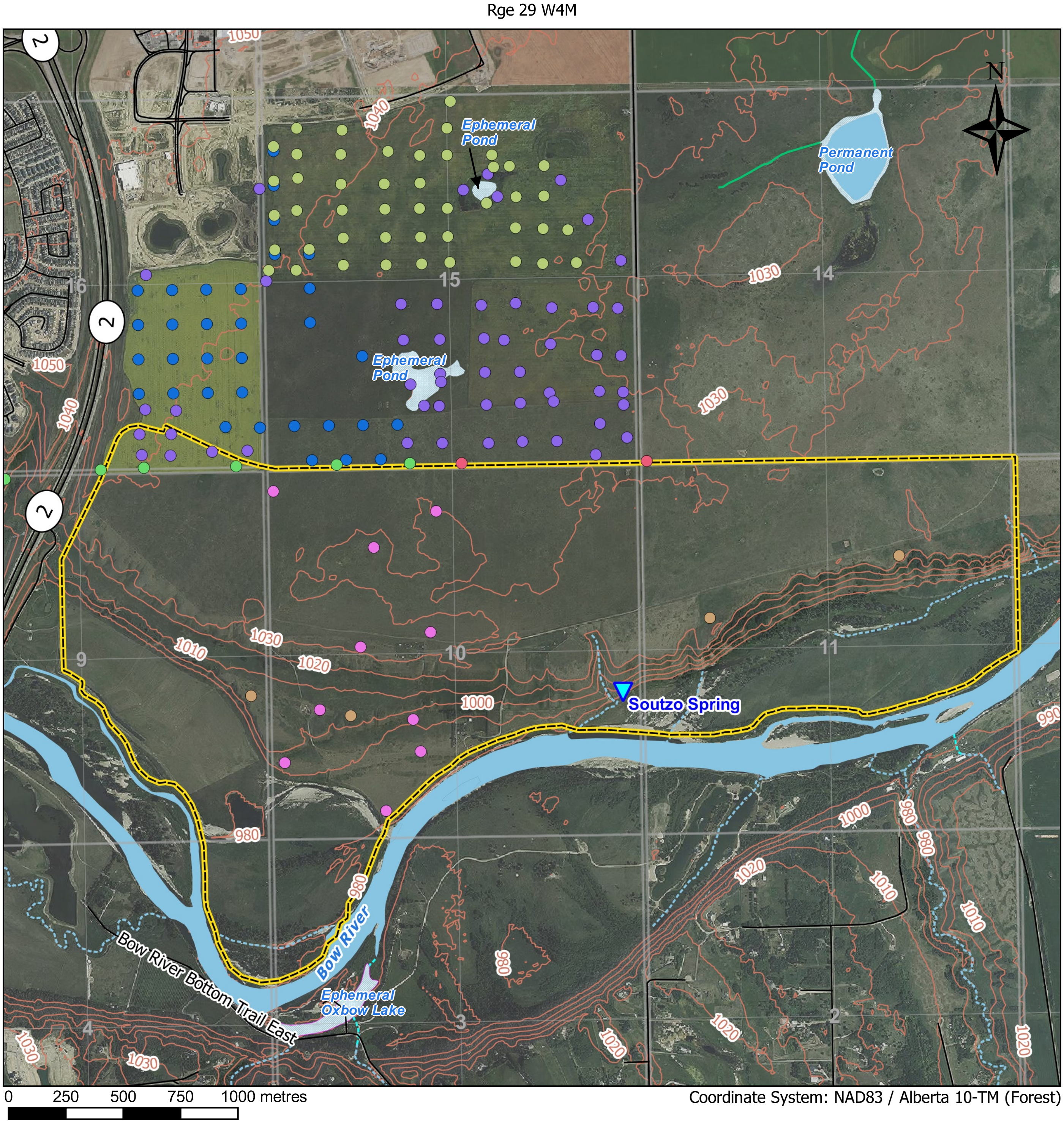
Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan Southeast
Calgary, Alberta

LOCATION PLAN

Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT NUMBER: 2961-18-001
COMPILED BY: GIS
DATE ISSUED: June 12, 2018

FIGURE 1



Ricardo Ranch ASP

Boreholes
- AECOM 2017
- Golder 2014
- McIntosh Lalani
- ML 2012
- ML 2014-2015
- Stantec 2014
- Thurber 2007
- Soutzo Spring

- Road
- Permanent Lake, River
- Ephemeral Lake
- Ephemeral Oxbow Lake
- Ephemeral Stream
- Ephemeral Drainage Pathway
- Man-made Canal/Ditch/Spillway
- 10 m Topographic Contour
- Quarter Section
- Section

References:

AltaLIS Base Features (2015), AltaLIS Lidar15 (2017), National Road Network (2016), Esri World Imagery.

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

SITE TOPOGRAPHY AND GEOTECHNICAL BOREHOLE LOCATIONS

Waterline

Prepared By: Waterline Resources Inc.
Project Number: 2961-18-001
Compiled By: jmusulak
Date Issued: 2018-Nov-05
Date Revised: --

FIGURE 2

P:\2018 PROJECTS\2961-18 Genesis Ricardo Ranch Rangeview Cell E\001 Preliminary Hydrogeological Assessment\Data\Drafting\2961-18-001 figs qgis3.qgz

Ricardo Ranch ASP

Surficial Geology

- Glacial Undivided Till (Gt)
- Crossfield Formation Till (Crt)
- Fluvial Channel Gravel (Hg; Gg)
- Fluvial Channel Sand (Crs; Us)
- Loamy Overbank and Fan Sediment (Ha)
- Pond Sediment (Hp)
- Loess (Hl)

- Road
- Quarter Section
- Section
- Permanent Lake, River
- Ephemeral Lake
- Ephemeral Oxbow Lake
- Ephemeral Stream
- Ephemeral Drainage Pathway
- Man-made Canal/Ditch/Spillway

References:

AltaLIS Base Features (2015), Moran, S. (1986), National Road Network (2016), Esri World Imagery.

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Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

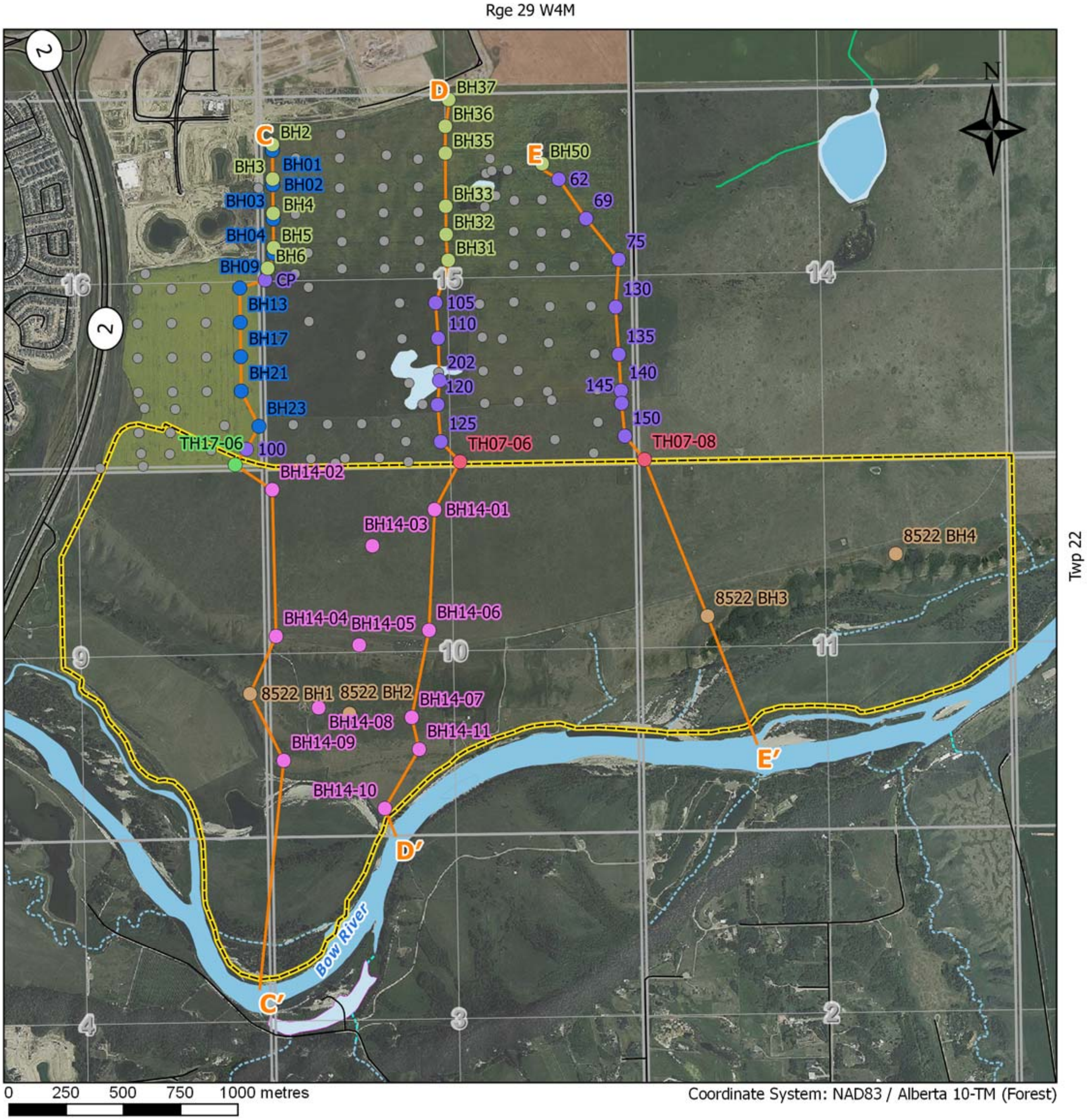
SURFICIAL GEOLOGY

Waterline

Prepared By: Waterline Resources Inc.
Project Number: 2961-18-001
Compiled By: jmusulak
Date Issued: 2018-Jul-12
Date Revised: --

FIGURE 3

P:\2018 PROJECTS\2961-18 Genesis Ricardo Ranch Rangeview Cell E\001 Preliminary Hydrogeological Assessment\Data\Drafting\2961-18-001 figs.qgs



- Ricardo Ranch ASP

Boreholes

- AECOM 2017
- Golder 2014
- McIntosh Lalani
- ML 2012
- ML 2014-2015
- Stantec 2014
- Thurber 2007
- Non-Picks

- Cross-Section Trace
- Road
- Quarter Section
- Section
- Permanent Lake, River
- Ephemeral Lake
- Ephemeral Oxbow Lake
- Ephemeral Stream
- Ephemeral Drainage Pathway
- Man-made Canal/Ditch/Spillway

References:

AltaLIS Base Features (2015), National Road Network (2016), Esri World Imagery.

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Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

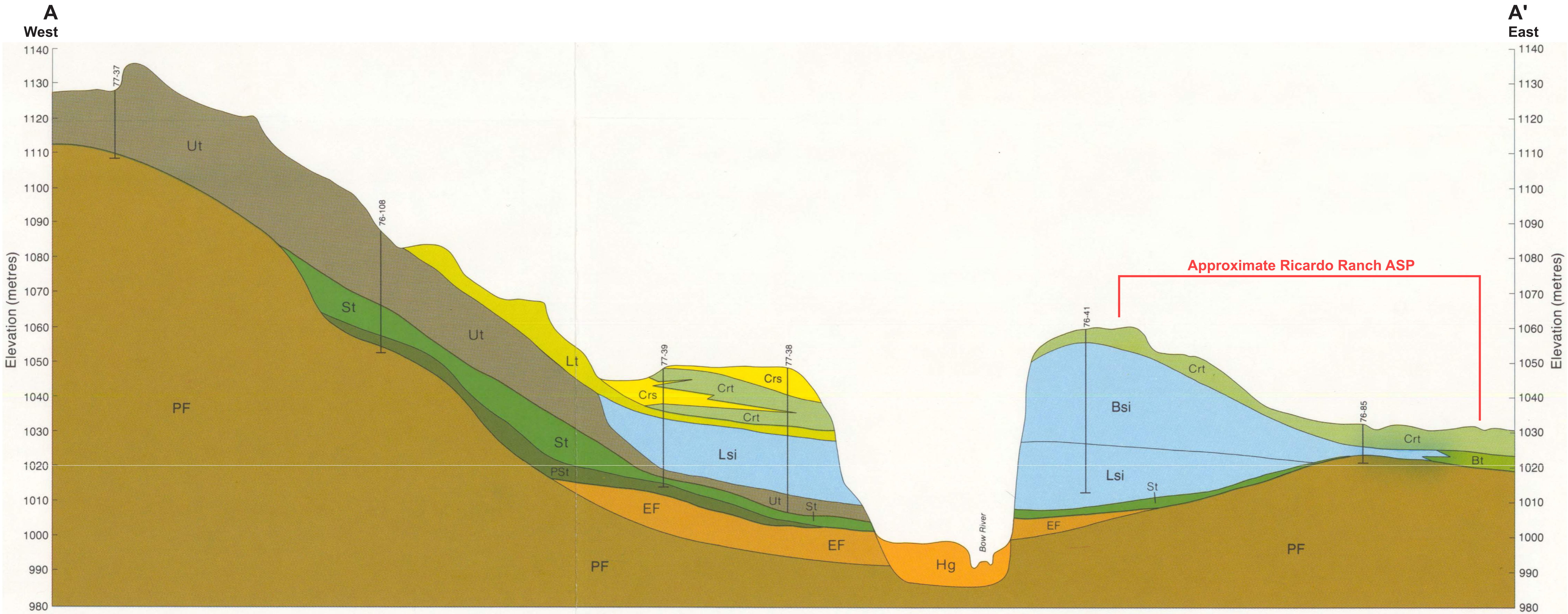
CROSS-SECTION TRACES

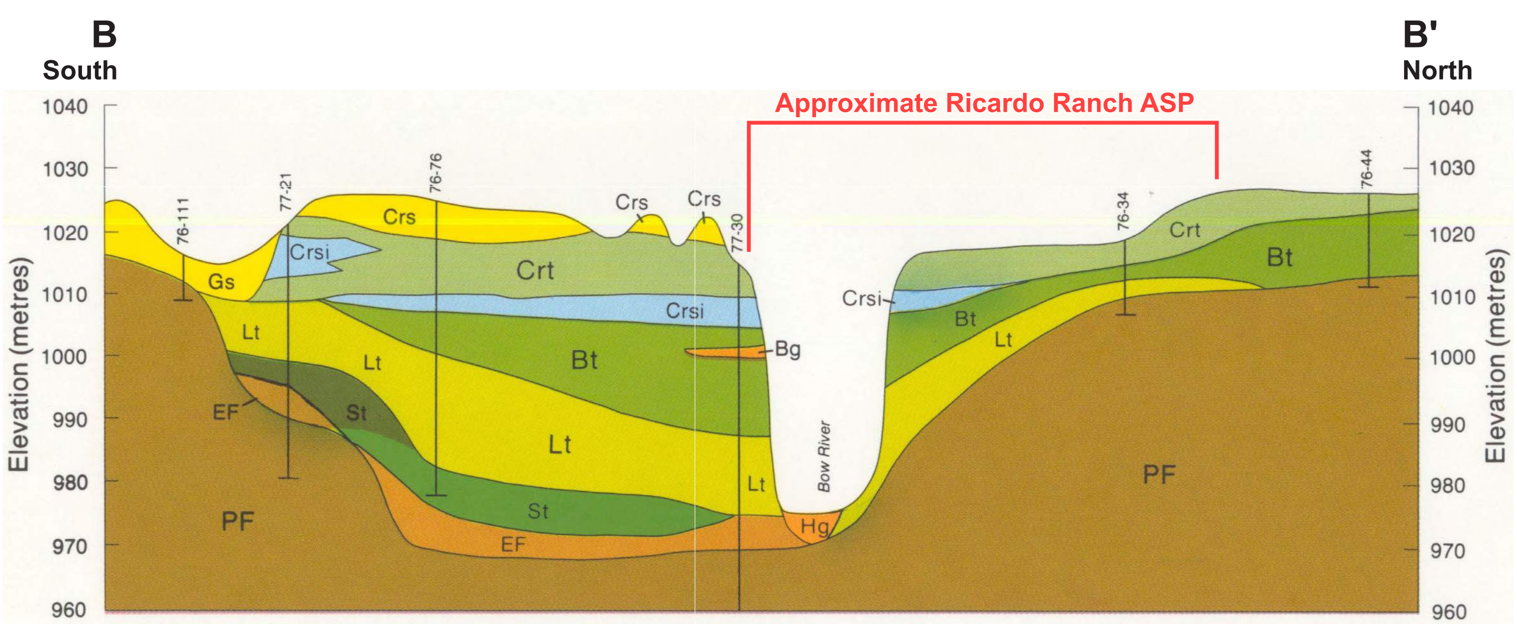
Waterline

Prepared By:	Waterline Resources Inc.
Project Number:	2961-18-001
Compiled By:	jmusulak
Date Issued:	2018-Jul-12
Date Revised:	--

FIGURE 4

P:\2018 PROJECTS\2961-18 Genesis Ricardo Ranch Rangeview Cell E\001 Preliminary Hydrogeological Assessment\Data\Drafting\2961-18-001 figs.qgs

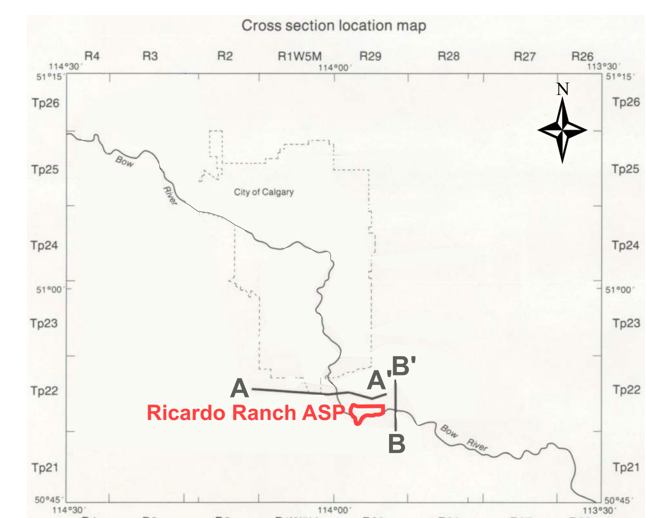




LEGEND:

	Lithogenetic Units			
Quaternary	Till	Silty Lacustrine	Fluvial Channel Sand	Fluvial Channel Gravel
Post-Glacial Undivided				Hg
Glacial Undivided			Gs	
Crossfield Formation	Crt	Crsi	Crs	
Balzac Formation	Bt	Bsi		Bg
Lochend Formation	Lt	Lsi		
Spy Hill Formation (Upper Unit)	Ut			
Spy Hill Formation (Lower Unit)	St			
Pre-Spy Hill	PSt			
Tertiary				
Empress Formation				EF
Paleocene and Cretaceous				
Porcupine Hills Formation	PF			

Stratigraphic Units



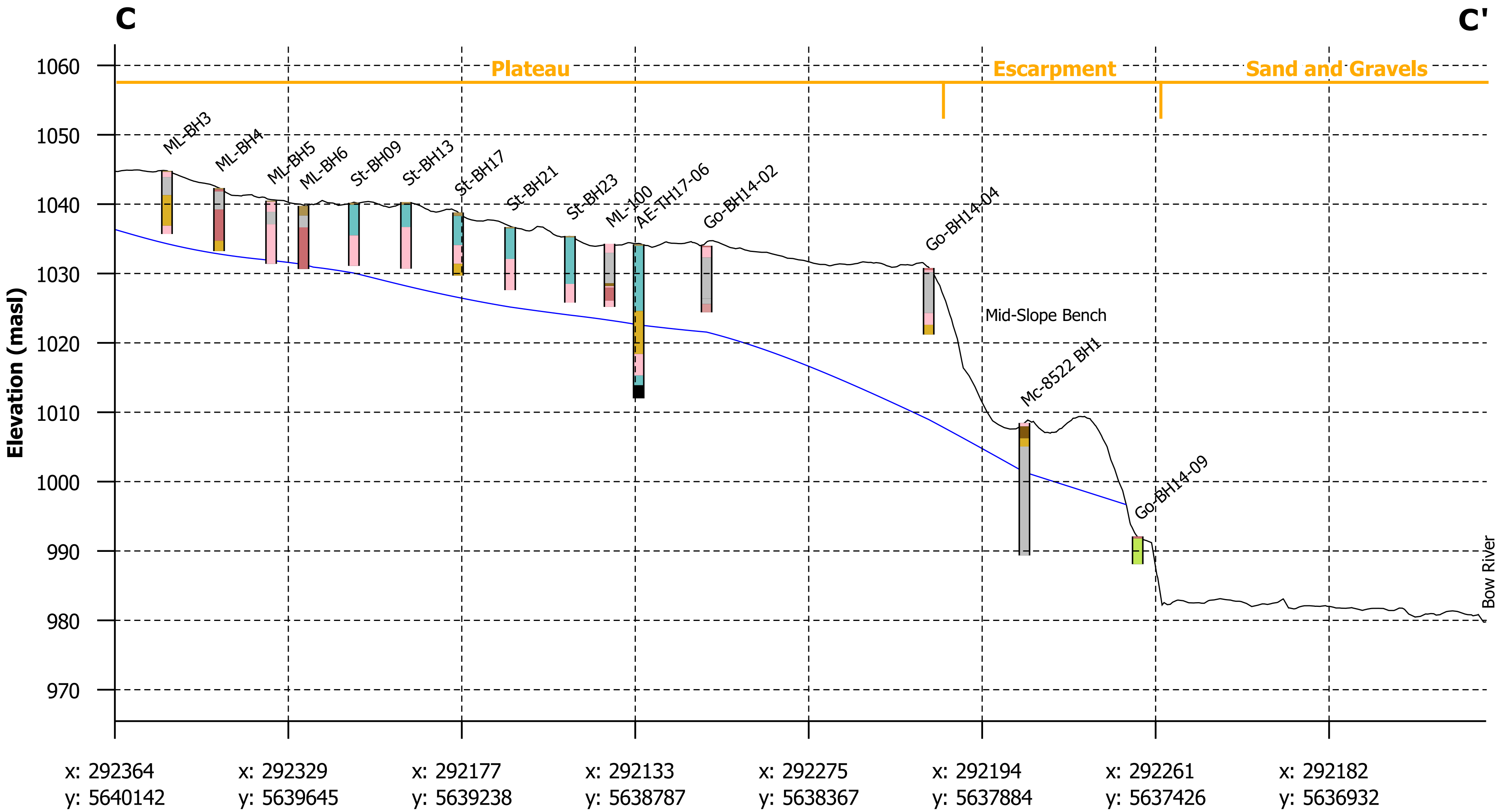
PROJECT
Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE
REGIONAL CROSS-SECTIONS A AND B

Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 5



LEGEND:

Water Table

Lithology

- Clay (till)
- Gravel
- Sand
- Sand and Gravel
- Sand and Silt
- Sandy Gravel
- Sandy Silt
- Sandy Silt and Gravel
- Silt (Till)
- Silt and Sand
- Silty Clay (Till)
- Silty Sand
- Silty Sand and Gravel
- Topsoil

Scale: 1:17,000

Vertical exaggeration: 20x

0m 1000m

PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE

HYDROGEOLOGICAL CROSS-SECTION C-C'

Waterline

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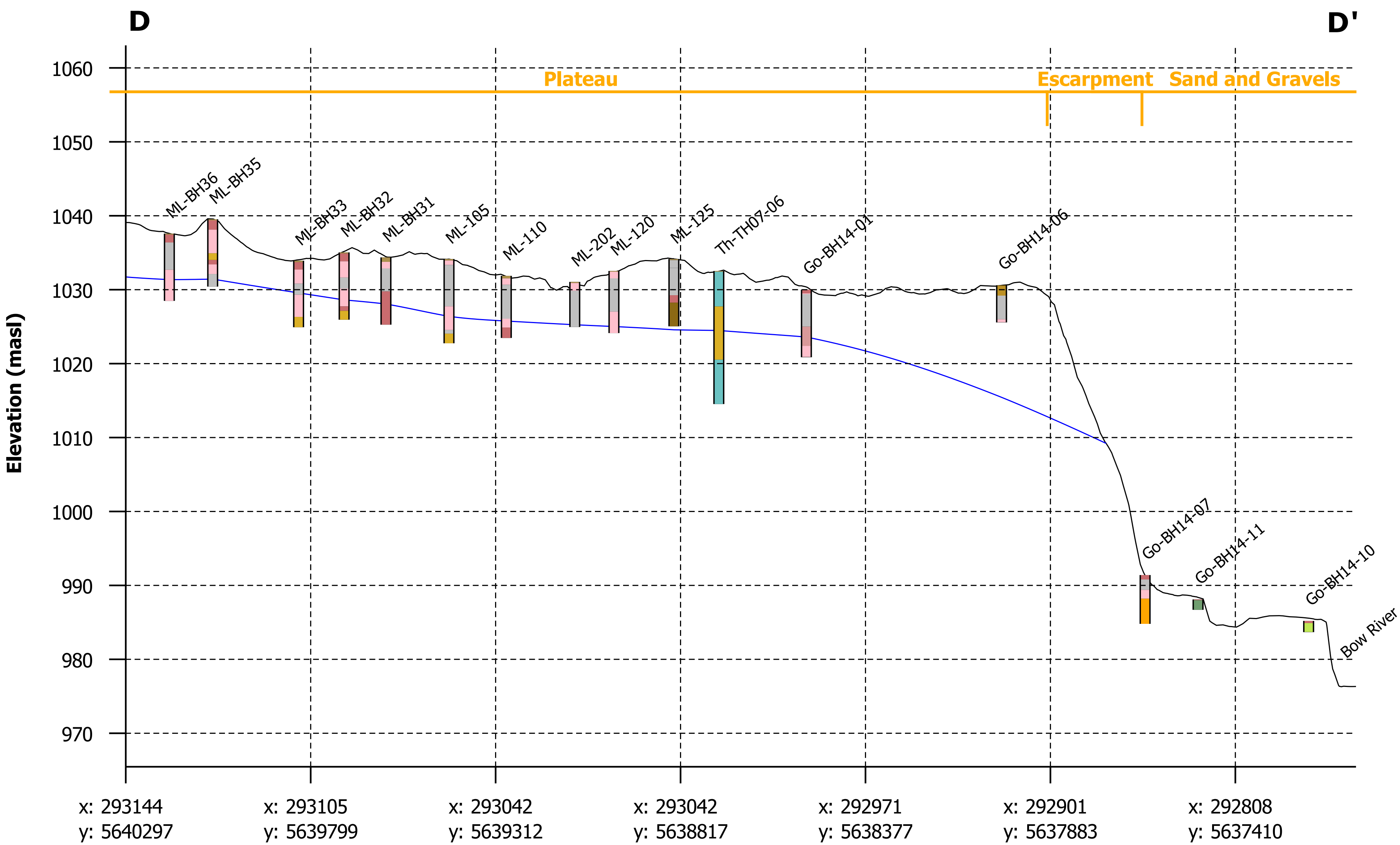
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 6



LEGEND:

Water Table

Lithology

- Clay (till)
- Gravel
- Sand
- Sand and Gravel
- Sand and Silt
- Sandy Gravel
- Sandy Silt
- Sandy Silt and Gravel
- Silt (Till)
- Silt and Sand
- Silty Clay (Till)
- Silty Sand
- Silty Sand and Gravel
- Topsoil

Scale: 1:15,000

Vertical exaggeration: 20x

0m 1000m

PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE

HYDROGEOLOGICAL CROSS-SECTION D-D'

Waterline

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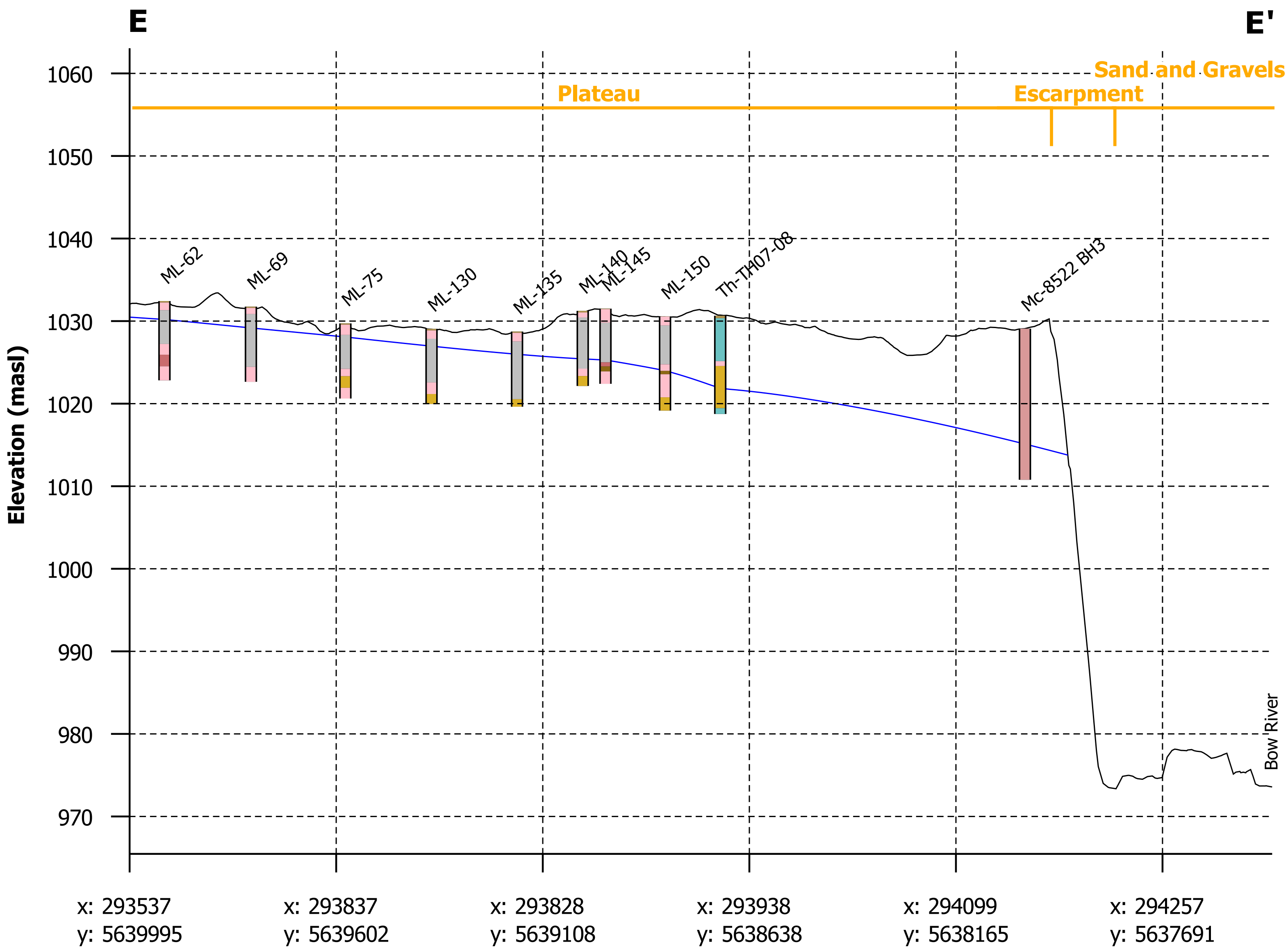
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 7



LEGEND:

Water Table

Lithology

- Clay (till)
- Gravel
- Sand
- Sand and Gravel
- Sand and Silt
- Sandy Gravel
- Sandy Silt
- Sandy Silt and Gravel
- Silt (Till)
- Silt and Sand
- Silty Clay (Till)
- Silty Sand
- Silty Sand and Gravel
- Topsoil

Scale: 1:15,000

Vertical exaggeration: 20x

0m 1000m

PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE

HYDROGEOLOGICAL CROSS-SECTION E-E'

Waterline

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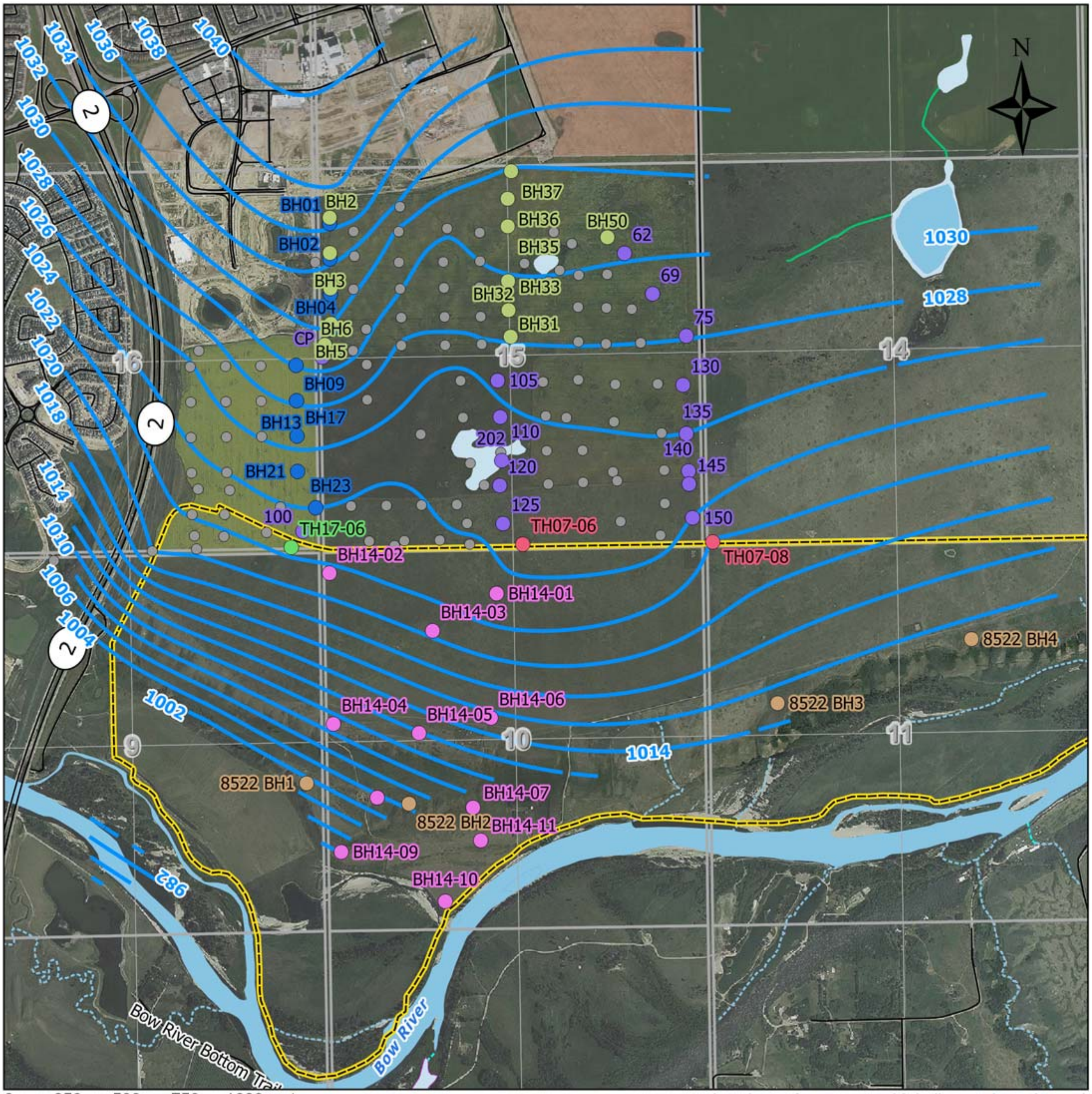
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 8

Rge 29 W4M



Twp 22

0 250 500 750 1000 metres

Coordinate System: NAD83 / Alberta 10-TM (Forest)

Ricardo Ranch ASP

Boreholes

- AECOM 2017
- Golder 2014
- McIntosh Lalani
- ML 2012
- ML 2014-2015
- Stantec 2014
- Thurber 2007
- Non-Picks

- Overburden Water Level Contours (masl)
- Road
- Quarter Section
- Section
- Permanent Lake, River
- Ephemeral Lake
- Ephemeral Oxbow Lake
- Ephemeral Stream
- Ephemeral Drainage Pathway
- Man-made Canal/Ditch/Spillway

References:

AltaLIS Base Features (2015), National Road Network (2016), Esri World Imagery.

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Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

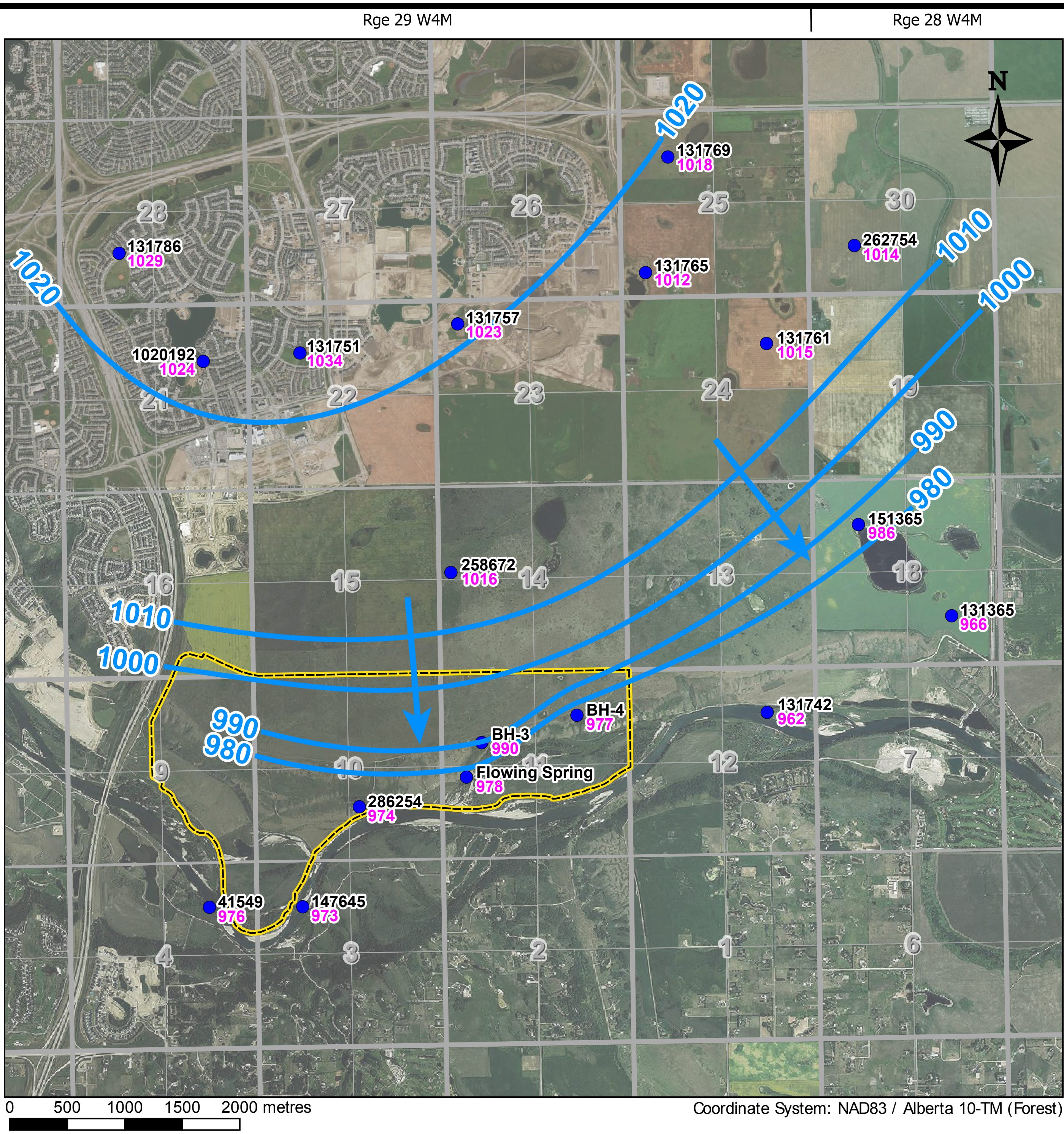
OVERBURDEN GROUNDWATER LEVEL CONTOUR MAP

Waterline

Prepared By:	Waterline Resources Inc.
Project Number:	2961-18-001
Compiled By:	jmusulak
Date Issued:	2018-Jul-12
Date Revised:	--

FIGURE 9

P:\2018 PROJECTS\2961-18 Genesis Ricardo Ranch Rangeview Cell E\001 Preliminary Hydrogeological Assessment\Data\Drafting\2961-18-001 figs.qgs



LEGEND:

Ricardo Ranch ASP

Road

ALBERTA TOWNSHIP SYSTEM

Quarter Section

Section

Water Well

286254 GIC Well ID Number

1010 Groundwater Elevation (masl)

Bedrock Water Level Contour (masl)

Groundwater Flow Direction

References:
AltaLIS Base Features (2015), National Road Network (2016), ESRI World Imagery
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PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE

BEDROCK GROUNDWATER LEVEL CONTOUR MAP

Waterline

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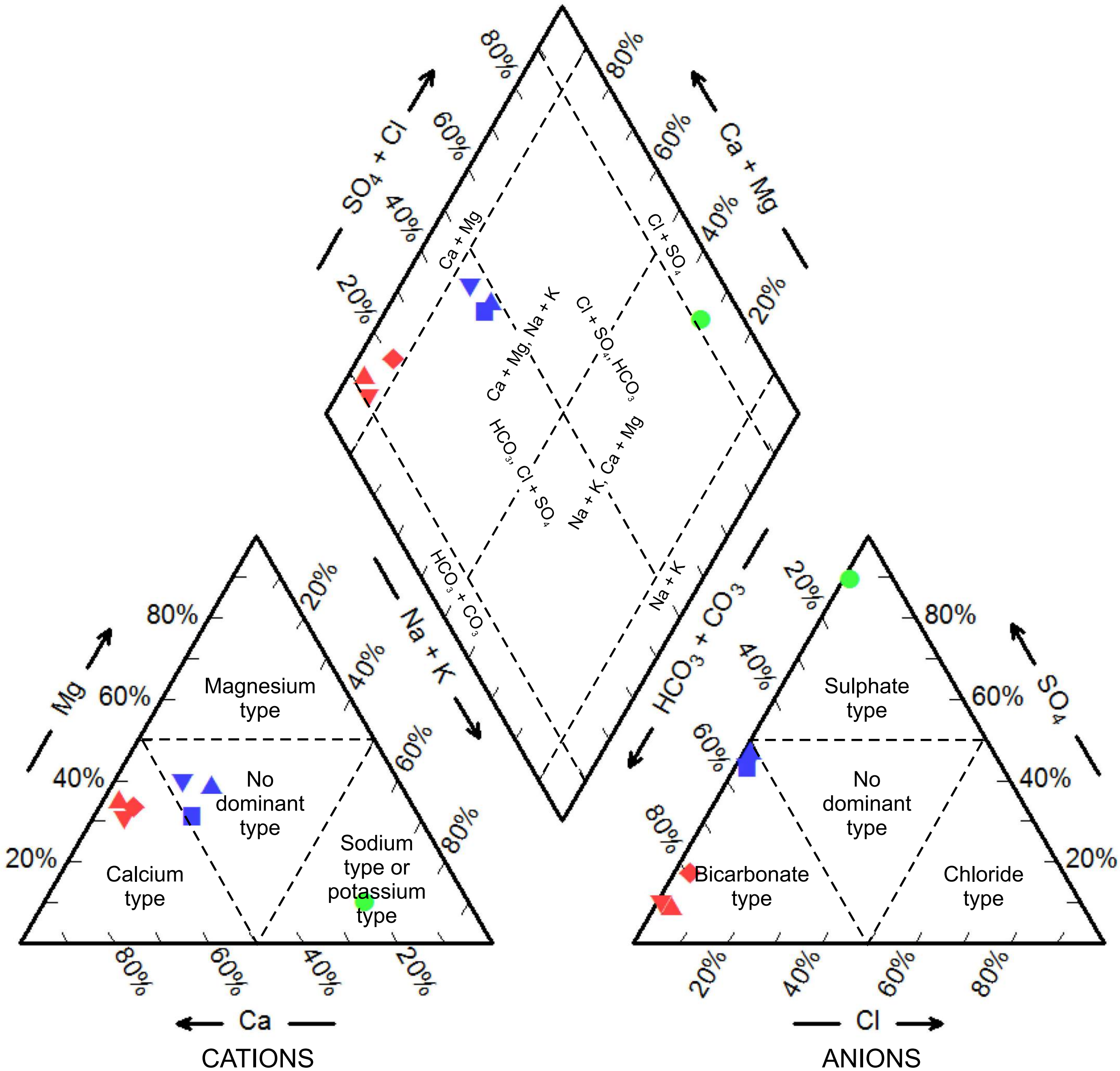
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: --

FIGURE 10



LEGEND:

Shallow Bedrock Aquifer

- East Spring (June 4, 2018)
- Soutzo Spring (June 4, 2018)
- GIC Well ID 131732 (July 5, 1977)

Till Aquifer

- MW17-06 (AECOM, 2017)
- MW17-07 (AECOM, 2017)
- MW17-08 (AECOM, 2017)

Deep Bedrock Aquifer

- GIC Well ID 131734 (June 4, 1979)

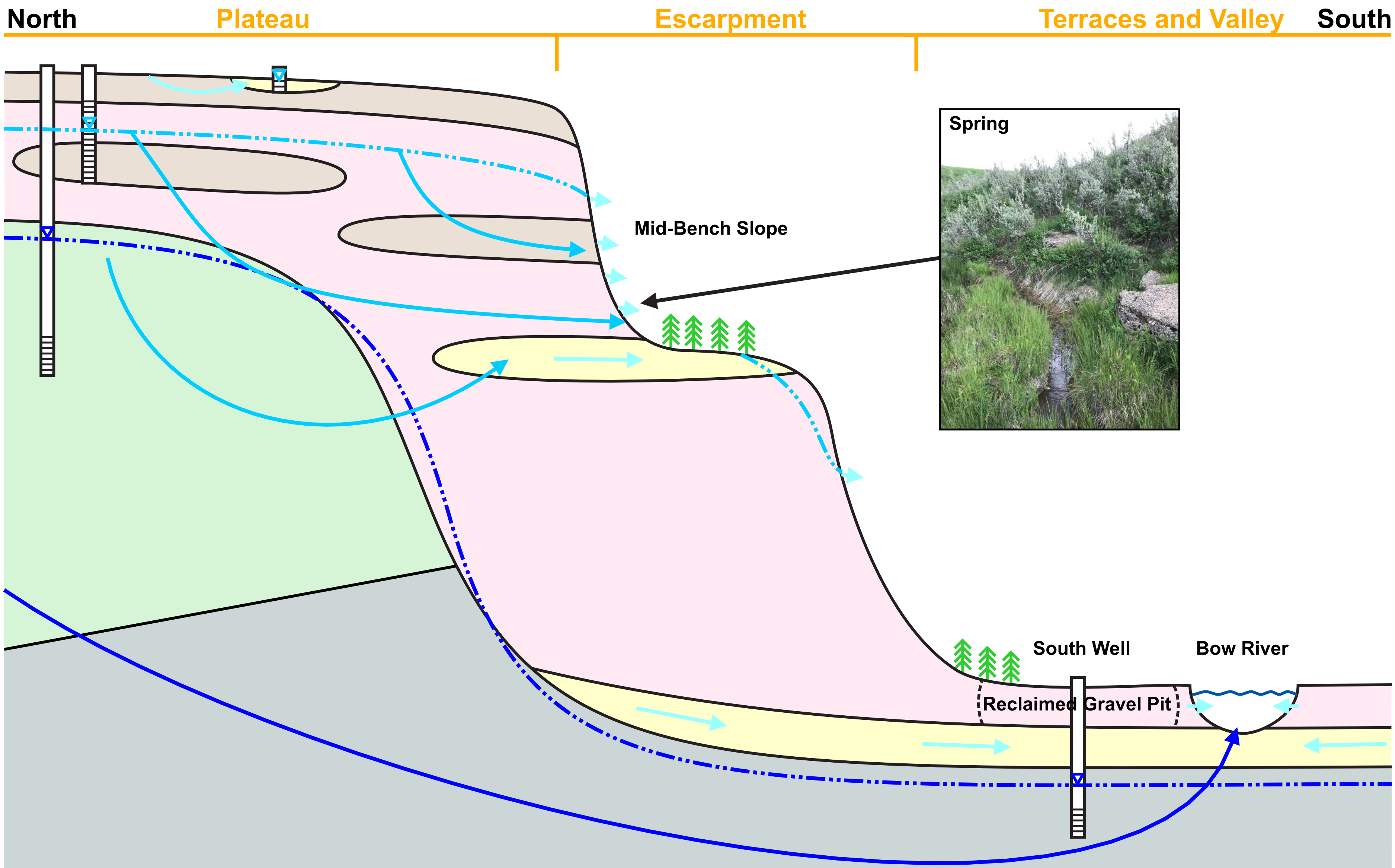
PROJECT
Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE
PIPER PLOT

Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 11



LEGEND:

- Water Table
- Paskapoo Formation Groundwater Level
- Local Flow System
- Intermediate Flow System
- Regional Flow System
- Glacial Till
- Silty Lacustrine
- Fluvial Sand and Gravel
- Paskapoo Formation (Bedrock)
- Scollard Formation (Bedrock)

PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

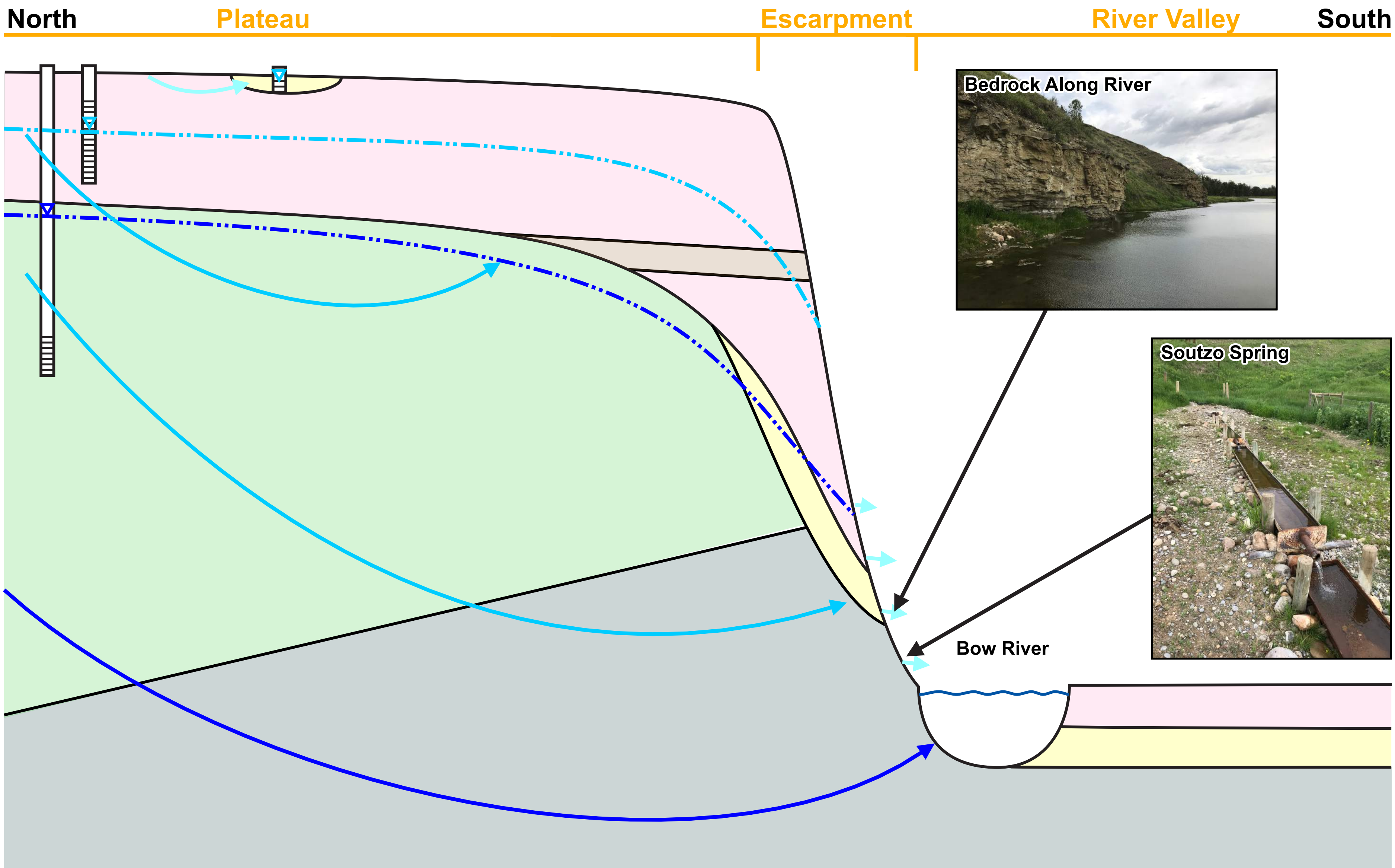
TITLE

CONCEPTUAL GROUNDWATER FLOW MODEL WEST ASP

Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 12



LEGEND:

Water Table	Glacial Till
Paskapoo Formation Groundwater Level	Silty Lacustrine
Local Flow System	Fluvial Sand and Gravel
Intermediate Flow System	Paskapoo Formation (Bedrock)
Regional Flow System	Scollard Formation (Bedrock)

PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE

CONCEPTUAL GROUNDWATER FLOW MODEL EAST ASP

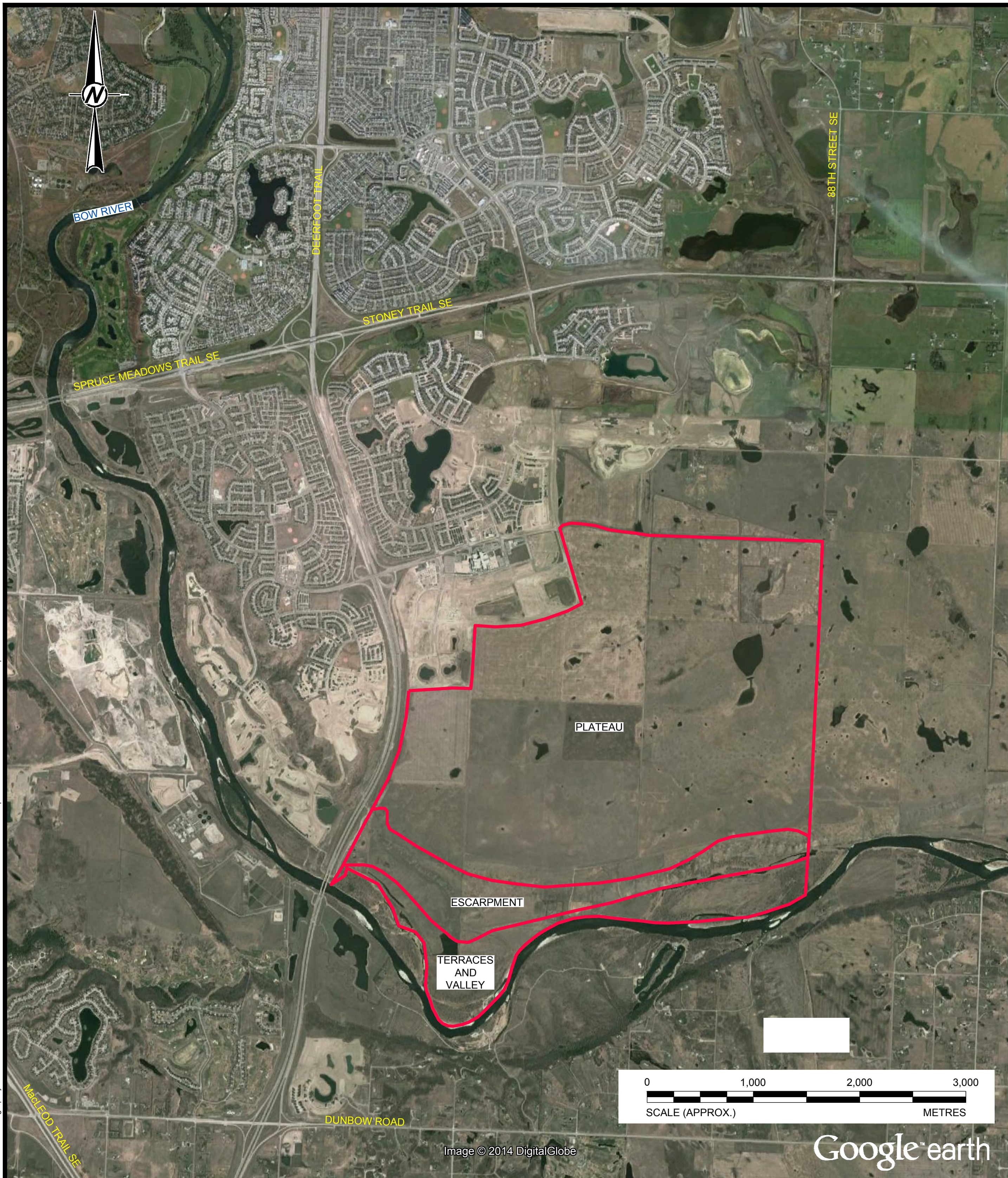
Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT: 2961-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE 13

Appendix A

Golder (2014) Desktop Hydrogeological Study



\\golder.gds\CAL\MCAD\2013\1334\13-1334-0069\13340069\3000\Report_A\13133400693000A002.dwg | Layout: THREE PHYSIOGRAPHIC T SETTINGS PLATEAU ESCARPMENT T AND V | Modified: BWheeler 02/07/2014 1:52 PM | Plotted: PStRose 03/04/2014

LEGEND

MASTER DRAINAGE PLAN STUDY AREA

REFERENCE

IMAGE OBTAINED FROM GOOGLE EARTH, USED UNDER LICENSE.
IMAGERY DATE: MAY 04, 2013. GOOGLE EARTH IMAGE IS NOT TO SCALE.
DATUM: NAD 83, PROJECTION: UTM ZONE 12.

PROJECT

RANGEVIEW AREA STRUCTURE PLAN
HYDROGEOLOGICAL ASSESSMENT

TITLE

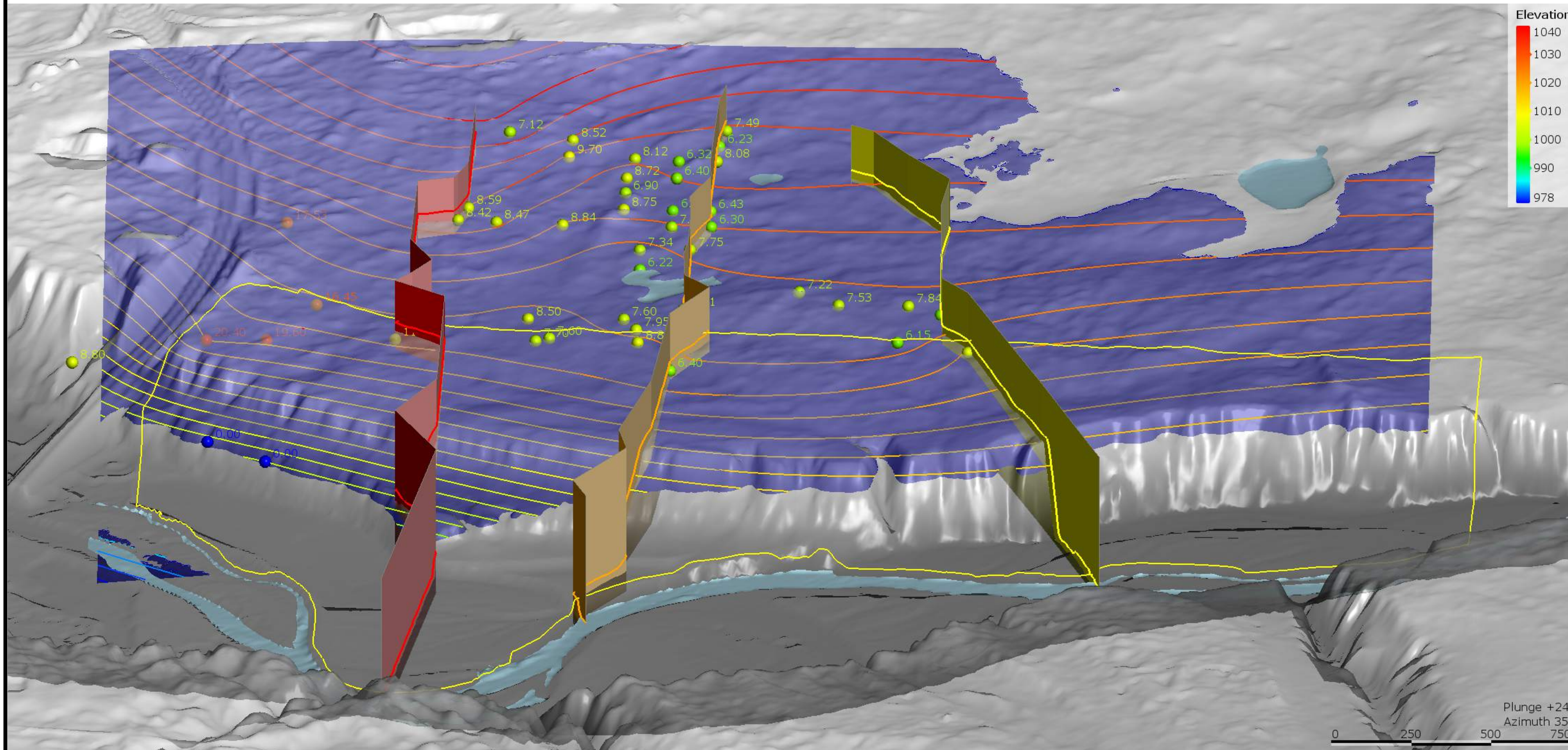
PHYSIOGRAPHIC TERRAIN IN THE MASTER DRAINAGE PLAN STUDY AREA

Golder Associates

PROJECT No.	13.1334.0069 .3000		FILE No.	13133400693000A002
DESIGN	BM	2014-02-04	SCALE	AS SHOWN
CADD	AW	2014-02-05		
CHECK	BM	2014-02-19	**FIGURE: 2**	
REVIEW	KCB	2014-02-19		

Appendix B

Waterline Data Compilation and Site Reconnaissance



PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

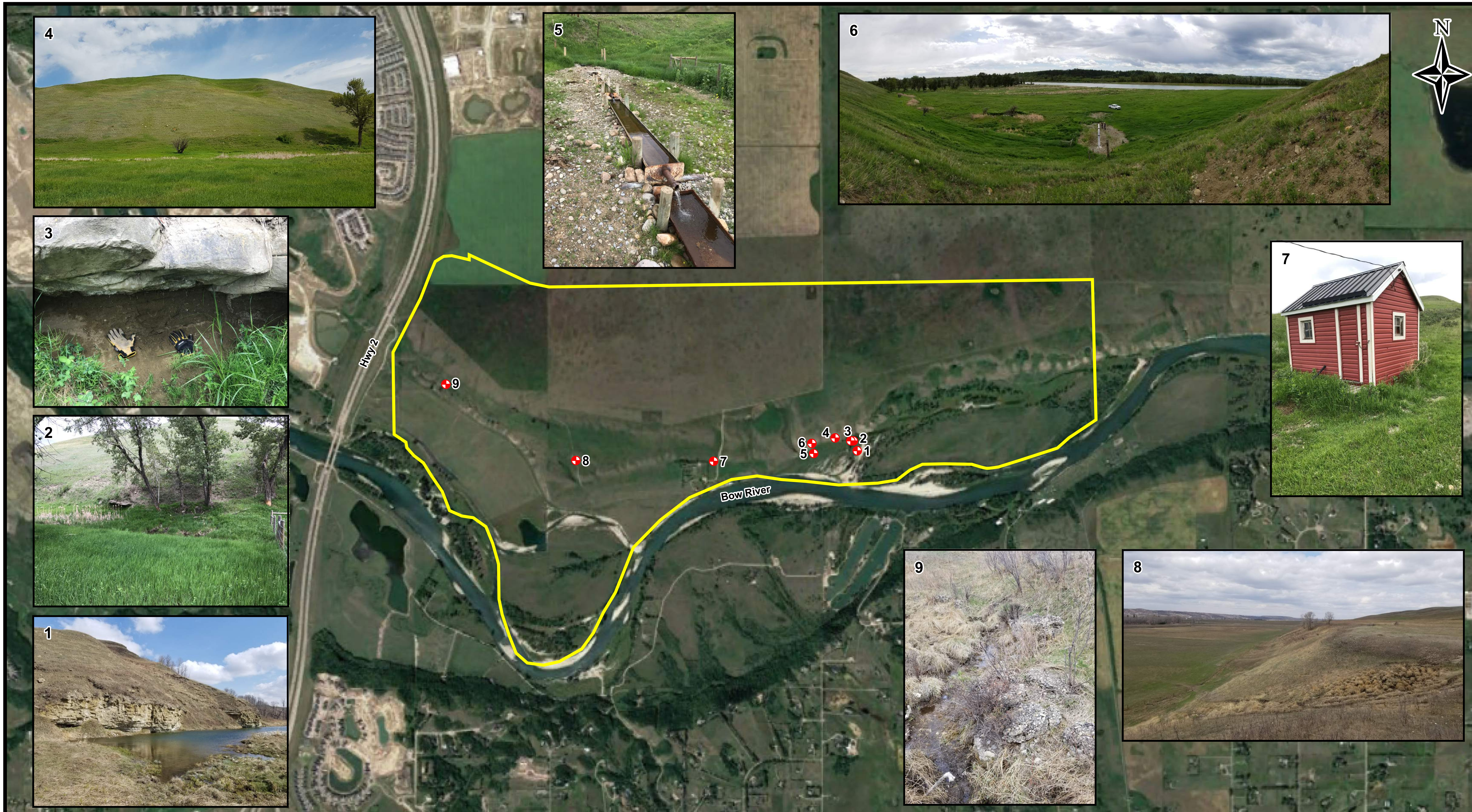
TITLE

DATA COMPILATION

Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT: 2943-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: --

FIGURE B-1



LEGEND:

Ricardo Ranch ASP

Reconnaissance Location

1 Bedrock outcrop with coarse-grained overburden above adjacent to Bow River channel
2 Bedrock-overburden interface
3 Groundwater seeps weathered sandstone from bedrock
4 Slumping along escarpment
5 Soutzo stock spring looking north toward escarpment
6 Soutzo stock spring and discharge looking south toward Bow River
7 Soutzo domestic use well
8 Vegetation growth and springs along west mid-bench
9 West med-bench spring and conglomerate boulders

REFERENCE: Google Earth, 2018

SCALE: 0 m 400 m 800 m

PROJECT

Preliminary Hydrogeological Assessment
Ricardo Ranch Area Structure Plan
Southeast Calgary, Alberta

TITLE

FIELD RECONNAISSANCE AND OBSERVATIONS

Waterline

PREPARED BY: Waterline Resources Inc.
PROJECT: 2943-18-001
COMPILED BY: CGD
DATE ISSUED: June 2018
REVISED: –

FIGURE B-2

Appendix C

Water Chemistry Results

Your Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Your C.O.C. #: 1 of 1

Attention: STEVE STURROCK

WATERLINE RESOURCES INC.
6415 - 10th Street S.E.
CALGARY, AB
CANADA T2H 2Z9

Report Date: 2018/06/11
Report #: R2569261
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B843351
Received: 2018/06/04, 17:54

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity @25C (pp, total), CO3,HCO3,OH	1	N/A	2018/06/06	AB SOP-00005	SM 22 2320 B m
Alkalinity @25C (pp, total), CO3,HCO3,OH	1	N/A	2018/06/07	AB SOP-00005	SM 22 2320 B m
Chloride by Automated Colourimetry	2	N/A	2018/06/10	AB SOP-00020	SM 22-4500-Cl-E m
Conductivity @25C	1	N/A	2018/06/06	AB SOP-00005	SM 22 2510 B m
Conductivity @25C	1	N/A	2018/06/07	AB SOP-00005	SM 22 2510 B m
Hardness	2	N/A	2018/06/06	AB WI-00065	Auto Calc
Elements by ICP-Dissolved-Lab Filtered (1)	2	N/A	2018/06/05	AB SOP-00042	EPA 200.7 CFR 2012 m
Ion Balance	2	N/A	2018/06/06	AB WI-00065	Auto Calc
Sum of cations, anions	2	N/A	2018/06/06	AB WI-00065	Auto Calc
Nitrate and Nitrite	2	N/A	2018/06/07	AB WI-00065	Auto Calc
Nitrate + Nitrite-N (calculated)	2	N/A	2018/06/07	AB WI-00065	Auto Calc
Nitrogen (Nitrite - Nitrate) by IC	2	N/A	2018/06/06	AB SOP-00023	SM 23 4110 B m
pH @25°C (2)	1	N/A	2018/06/06	AB SOP-00005	SM 22 4500-H+B m
pH @25°C (2)	1	N/A	2018/06/07	AB SOP-00005	SM 22 4500-H+B m
Sulphate by Automated Colourimetry	2	N/A	2018/06/10	AB SOP-00018	SM 22 4500-SO4 E m
Total Dissolved Solids (Calculated)	2	N/A	2018/06/10	AB WI-00065	Auto Calc

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.

Your Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Your C.O.C. #: 1 of 1

Attention: STEVE STURROCK

WATERLINE RESOURCES INC.
6415 - 10th Street S.E.
CALGARY, AB
CANADA T2H 2Z9

Report Date: 2018/06/11
Report #: R2569261
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B843351
Received: 2018/06/04, 17:54

Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) Samples were filtered and preserved at the lab. Values may not reflect concentrations at the time of sampling. Dissolved > Total Imbalance: Whenever applicable, Dissolved >Total for any parameter that falls within method uncertainty for duplicates is likely equivalent. If RPD is >20% samples were reanalyzed and confirmed.
(2) The CCME method requires pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the CCME holding time. Maxxam endeavours to analyze samples as soon as possible after receipt.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Cynny Hagen, Project Manager
Email: CHagen@maxxam.ca
Phone# (403)735-2273
==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam
A Bureau Veritas Group Company

Maxxam Job #: B843351
Report Date: 2018/06/11

WATERLINE RESOURCES INC.
Client Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Sampler Initials: JD

ROUTINE WATER -LAB FILTERED (WATER)

Maxxam ID					TO3581			TO3582			
Sampling Date					2018/06/04 11:09			2018/06/04 11:57			
COC Number					1 of 1			1 of 1			
	UNITS	**MAC**	**AO**	**OG**	**SPRING 1**	**MU**	**QC Batch**	**SPRING 2**	**MU**	**RDL**	**QC Batch**
Calculated Parameters											
Anion Sum	meq/L	-	-	-	14	N/A	9012387	14	N/A	N/A	9012387
Cation Sum	meq/L	-	-	-	15	N/A	9012387	14	N/A	N/A	9012387
Hardness (CaCO3)	mg/L	-	-	-	580	N/A	9012383	620	N/A	0.50	9012383
Ion Balance (% Difference)	%	-	-	-	1.4	N/A	9012385	1.0	N/A	N/A	9012385
Dissolved Nitrate (NO3)	mg/L	45	-	-	6.5	N/A	9012390	14	N/A	0.044	9012390
Nitrate plus Nitrite (N)	mg/L	-	-	-	1.5	N/A	9012391	3.1	N/A	0.014	9012391
Dissolved Nitrite (NO2)	mg/L	3	-	-	<0.033	N/A	9012390	<0.033	N/A	0.033	9012390
Calculated Total Dissolved Solids	mg/L	-	500	-	**820**	N/A	9012393	**800**	N/A	10	9012393
Misc. Inorganics											
Conductivity	uS/cm	-	-	-	1300	+/- 33	9015099	1200	+/- 32	2.0	9014156
pH	pH	-	-	7.0:10.5	8.08	+/- 0.0800	9015098	7.91	+/- 0.0784	N/A	9014154
Anions											
Alkalinity (PP as CaCO3)	mg/L	-	-	-	<1.0	N/A	9015095	<1.0	N/A	1.0	9014153
Alkalinity (Total as CaCO3)	mg/L	-	-	-	370	+/- 28	9015095	370	+/- 28	1.0	9014153
Bicarbonate (HCO3)	mg/L	-	-	-	450	+/- 7.0	9015095	460	+/- 7.1	1.0	9014153
Carbonate (CO3)	mg/L	-	-	-	<1.0	N/A	9015095	<1.0	N/A	1.0	9014153
Hydroxide (OH)	mg/L	-	-	-	<1.0	N/A	9015095	<1.0	N/A	1.0	9014153
Dissolved Sulphate (SO4)	mg/L	-	500	-	320 (1)	+/- 28	9019769	290 (1)	+/- 26	2.0	9019771
Dissolved Chloride (Cl)	mg/L	-	250	-	9.8	+/- 1.2	9019768	12	+/- 1.3	1.0	9019770
Nutrients											
Dissolved Nitrite (N)	mg/L	1	-	-	<0.010	N/A	9013708	<0.010	N/A	0.010	9013708
Dissolved Nitrate (N)	mg/L	10	-	-	1.5	+/- 0.13	9013708	3.1	+/- 0.28	0.010	9013708
Lab Filtered Elements											
Dissolved Calcium (Ca)	mg/L	-	-	-	120	+/- 12	9013733	130	+/- 13	0.30	9013733
Dissolved Iron (Fe)	mg/L	-	0.3	-	<0.060	N/A	9013733	<0.060	N/A	0.060	9013733
Dissolved Magnesium (Mg)	mg/L	-	-	-	70	+/- 4.5	9013733	69	+/- 4.4	0.20	9013733
Dissolved Manganese (Mn)	mg/L	-	0.05	-	<0.0040	N/A	9013733	<0.0040	N/A	0.0040	9013733
Dissolved Potassium (K)	mg/L	-	-	-	3.6	+/- <RDL	9013733	2.7	+/- <RDL	0.30	9013733
Dissolved Sodium (Na)	mg/L	-	200	-	73	+/- 7.2	9013733	47	+/- 4.6	0.50	9013733

No Fill	No Exceedance
Grey	Exceeds 1 criteria policy/level
Black	Exceeds both criteria/levels

RDL = Reportable Detection Limit
MU = Measurement Uncertainty
N/A = Not Applicable
(1) Detection limits raised due to dilution to bring analyte within the calibrated range.

Maxxam Analytics International Corporation o/a Maxxam Analytics Calgary: 2021 - 41st Avenue N.E. T2E 6P2 Telephone (403) 291-3077 Fax (403) 291-9468

Maxxam Job #: B843351
Report Date: 2018/06/11

WATERLINE RESOURCES INC.
Client Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Sampler Initials: JD

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	3.3°C

MAC,AO,OG: The guidelines that have been included in this report have been taken from the Canadian Drinking Water Quality Summary Table, February 2017.

Criteria A = Maximum Acceptable Concentration (MAC) / Criteria B = Aesthetic Objectives (AO) / Criteria C = Operational Guidance Values (OG)
It is recommended to consult these guidelines when interpreting your data since there are non-numerical guidelines that are not included on this report.

Turbidity Guidelines:
1. Chemically assisted filtration: less than or equal to 0.3 NTU in 95% of the measurements or 95% of the time each month. Shall not exceed 1.0 NTU at any time.
2. Slow sand / diatomaceous earth filtration: less than or equal to 1.0 NTU in 95% of the measurements or 95% of the time each month. Shall not exceed 3.0 NTU at any time.
3. Membrane filtration: less than or equal to 0.1 NTU in 99% of the measurements made or at least 99% of the time each calendar month. Shall not exceed 0.3 NTU at any time.
4. To ensure effectiveness of disinfection and for good operation of the distribution system, it is recommended that water entering the distribution system have turbidity levels of 1.0 NTU or less.

The estimate of uncertainty has been reported as an expanded uncertainty and calculated using a coverage factor of 2, which gives a level of confidence of 95%.

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

WATERLINE RESOURCES INC.
Client Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Sampler Initials: JD

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
9013708	Dissolved Nitrate (N)	2018/06/06	102	80 - 120	102	80 - 120	<0.010	mg/L	NC	20
9013708	Dissolved Nitrite (N)	2018/06/06	103	80 - 120	97	80 - 120	<0.010	mg/L	NC	20
9013733	Dissolved Calcium (Ca)	2018/06/05	105	80 - 120	101	80 - 120	<0.30	mg/L	0.67	20
9013733	Dissolved Iron (Fe)	2018/06/05	102	80 - 120	94	80 - 120	<0.060	mg/L	0.50	20
9013733	Dissolved Magnesium (Mg)	2018/06/05	103	80 - 120	100	80 - 120	<0.20	mg/L	0.85	20
9013733	Dissolved Manganese (Mn)	2018/06/05	104	80 - 120	100	80 - 120	<0.0040	mg/L	4.1	20
9013733	Dissolved Potassium (K)	2018/06/05	105	80 - 120	95	80 - 120	<0.30	mg/L	0.17	20
9013733	Dissolved Sodium (Na)	2018/06/05	NC	80 - 120	91	80 - 120	<0.50	mg/L	0.27	20
9014153	Alkalinity (PP as CaCO3)	2018/06/06					<1.0	mg/L	NC	20
9014153	Alkalinity (Total as CaCO3)	2018/06/06			98	80 - 120	<1.0	mg/L	1.2	20
9014153	Bicarbonate (HCO3)	2018/06/06					<1.0	mg/L	1.2	20
9014153	Carbonate (CO3)	2018/06/06					<1.0	mg/L	NC	20
9014153	Hydroxide (OH)	2018/06/06					<1.0	mg/L	NC	20
9014154	pH	2018/06/06			100	97 - 103			0.28	N/A
9014156	Conductivity	2018/06/06			99	90 - 110	<2.0	uS/cm	2.1	10
9015095	Alkalinity (PP as CaCO3)	2018/06/07					<1.0	mg/L	NC	20
9015095	Alkalinity (Total as CaCO3)	2018/06/07			96	80 - 120	<1.0	mg/L	NC	20
9015095	Bicarbonate (HCO3)	2018/06/07					<1.0	mg/L	NC	20
9015095	Carbonate (CO3)	2018/06/07					<1.0	mg/L	NC	20
9015095	Hydroxide (OH)	2018/06/07					<1.0	mg/L	NC	20
9015098	pH	2018/06/07			99	97 - 103			0.74	N/A
9015099	Conductivity	2018/06/07			100	90 - 110	<2.0	uS/cm	NC	10
9019768	Dissolved Chloride (Cl)	2018/06/10	NC	80 - 120	105	80 - 120	<1.0	mg/L	1.0	20
9019769	Dissolved Sulphate (SO4)	2018/06/10	NC	80 - 120	105	80 - 120	<1.0	mg/L	1.7	20
9019770	Dissolved Chloride (Cl)	2018/06/10	107	80 - 120	104	80 - 120	<1.0	mg/L	0.24	20

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QUALITY ASSURANCE REPORT(CONT'D)

WATERLINE RESOURCES INC.
Client Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Sampler Initials: JD

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**UNITS**	**Value (%)**	**QC Limits**
9019771	Dissolved Sulphate (SO4)	2018/06/10	NC	80 - 120	104	80 - 120	<1.0	mg/L	0.37	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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WATERLINE RESOURCES INC.
Client Project #: 2961-18-001
Site Location: GENESIS RICARDO RANCH CELL E
Sampler Initials: JD

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Harry (Peng) Liang, Senior Analyst

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Exceedence Summary Table – 2017 Canadian DW Quality

Result Exceedences

Sample ID	Maxxam ID	Parameter	Criteria	Result	DL	Units
No Exceedences						
The exceedence summary table is for information purposes only and should not be considered a comprehensive listing or statement of conformance to applicable regulatory guidelines.						